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EDITORIAL

THE IMPORTANCE OF THE INDIVIDUAL

Science in all its branches has made such stupendous advances in the last hundred years that it seemed that the barriers of ignorance had at last been broken down and Utopia was at hand. In the realm of medical endeavour great discoveries have disclosed the true nature of many pathological processes that affect both animals and man, and one by one many diseases have been resolved, prevented and in some cases eliminated. The history of the world is a study in panoramic form of change in the conditions of life and man's reaction to his inconstant environment. Socially and politically great progress has been made. Each generation has witnessed an improvement in the standard of life and the conquest of some social evil which had previously excited the opprobrium of the people. It is a strange fact that concurrently with these mutations in the way of life there have been somewhat similar alterations in the type and incidence of the diseases and in some respect the abnormalities which affect man and animals. We have proof that many diseases, particularly those of germ origin, have a history which in point of time parallels that of man. Every now and then after a period of relative quiescence, in which the victims might be lulled into a false security, they would resuscitate with a catastrophic vigour and rage the world by pestilence.

(The March issue of The British Veterinary Journal was published on March 25)

We have proof also that many of the diseases, the accidental injuries and the structural abnormalities which assail and incapacitate the individual and make life a burden of pain and suffering were well known even to our most ancient ancestors. These things, however, were local in their effects; they could bring pain and sorrow to an individual and his friends in the immediate vicinity but they did not rage at large with lethal terror amongst the populace.

The discovery that living organisms were the initial cause of many pathological processes marked the beginning of an epoch of success in the fight to alleviate, and in many instances, repel and conquer the constant attrition of disease. As our knowledge of natural history has advanced and the true nature of the life and machinations of harmful germs has been disclosed, many diseases have been brought under control and bid fair to suffer elimination. To join in the fight against the diseases that run like a fire amongst man and animals has been an attractive job for research workers for the last 100 years. Great things have been achieved. The fight against disease affecting the mass has tended to a neglect of the sorrows of the individual.

It is good to see that at last scientific effort is being attracted to this field. As knowledge advances we find that many ideas and conceptions were founded in error. Tissues which were thought to be almost immune from abnormality are now designated as frequent and constant culprits. Probably the best example of this aberration is the inter-vertebral disc. This fibro elastic pad, so resilient and apparently so firmly controlled by ligamentous and bony attachments that one did not suspect that it could stray from its normal position, except when the body was the subject of gross trauma, is now arraigned as the sponsor of many evils previously designated as lumbago, fibrositis and sciatica in man and with some modification in terminology in dogs also. The term "slipped disc" is dramatic but unfortunate in design. It tends to imply the popping out of the disc as a whole just as one expects the slot machine to produce a bar of chocolate when a coin is inserted. This is, of course, far from the truth and the article which we publish in this issue will do much to rectify such an idea.

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GENERAL ARTICLES

A COMPARISON OF THE ANATOMY OF THE INTERVERTEBRAL DISC IN DOG AND MAN

With reference to herniation of the nucleus pulposus

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SINCE 1934 disturbance of the intervertebral disc has been established as a common cause of significant nervous symptoms in man (Bradford and Spurling, 1945, p. 6). Relatively recent work, reviewed by Smith and King (1954), has suggested that herniation of the nucleus pulposus (disc protrusion) is an important clinical entity in the dog also.

It is perhaps possible that comparisons of the various aspects of disc disease in man and dog may become of increasing interest. It would be a special field for the comparative pathologist, and veterinary clinicians may seek to exploit techniques of diagnosis, treatment, etc., used in man. Orthopædic surgeons may turn to the dog for further experimental researches, for as Lob (1933) has emphasised there are particular advantages in the experimental approach to the investigation of disc disease. There are also indications of a more general interest on the part of physicians and pathologists. For example, the recent textbook on diseases of the human spine by Lindemann and Kuhlendahl (1953) includes a comparative section on the diseases of the canine disc. A fairly comprehensive comparison of the anatomy of the disc would appear to be an essential basis for all such comparisons of its diseases.

It seems that up to the present no such comparison has been published. In the anatomical section of his monograph Hansen (1952) made some comparisons with man, but these were mainly incidental to his account of the canine disc. The only comparative comment found in the British literature appears to be that by Boddie (1949) who stated that disc prolapse in a manner comparable to that seen in man is anatomically impossible in the dog; however, the emphasis of the article was clinical and the anatomical basis of this conclusion was not given.

In the following report we have described the adult canine disc and then compared it with the human disc. We have drawn freely on the abundant literature on the anatomy of the human disc. The canine disc has received relatively little attention. Only two extensive accounts are available, namely those of Baum and Zietzschmann (1936) and Hansen (1952), and neither of these is fully comprehensive. We have made observations to confirm the gross anatomy in these works, and have been able to add some new details.

Finally, we have discussed the possible influence on herniation of the nucleus pulposus of the anatomical differences which are found to exist between the two species.

Materials and Methods

Ten unpreserved cadavers of normal dogs of varying ages and breeds were prepared in the following four stages. First the vertebral column from atlas to sacrum was removed, the ribs being cut back to the same length as the lumbar transverse processes. Secondly the axial muscles were trimmed away and the neural arches and spinal cord removed. Thirdly the column was divided vertically along the mid-line by a hand-saw, using the dorsal longitudinal ligament as a guide. Fourthly a radiograph was taken from a lateral view of each disc in one half of the divided column.

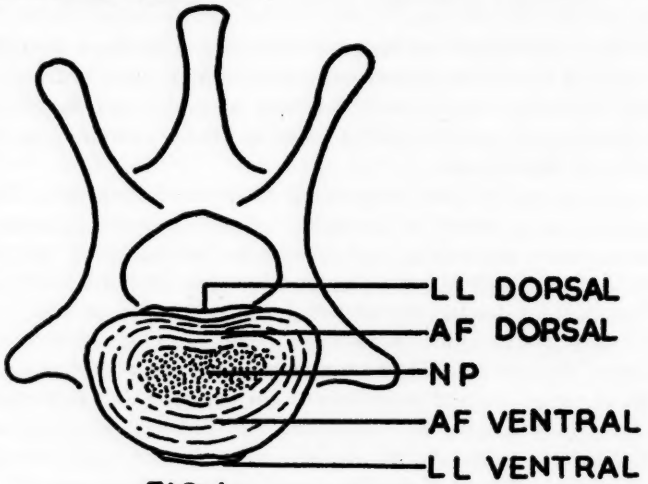

FIG. 1

Semi-diagrammatic transverse section of the first lumbar disc of the dog, to show its general anatomy. AF = annulus fibrosus. NP = nucleus pulposus. LL = longitudinal ligament.

The following observations were made at each of these stages. Stage 1 : the mobility of the vertebral column; dorsal, ventral, and lateral flexion were assessed for the cervical, thoracic, and lumbar regions by direct manipulation and observation. Stage 2 : the distribution of the conjugal ligament and the relationship of the dorsal and ventral longitudinal ligaments to the discs were noted. Stage 3 : various observations were made on the nucleus pulposus and annulus fibrosus, including the presence of turgescence and the variations in colour and consistency, etc., of the nucleus pulposus, and the relative thickness of the dorsal and ventral parts of the annulus fibrosus. Stage 4 : the minimum cranio-caudal thickness of each disc was measured on the radiograph.

On seven preserved cadavers of normal dogs of varying ages and breeds a mid-cervical, mid-thoracic and mid-lumbar disc were cut transversely and the architecture and number of the lamellæ and the nature of the cartilage plate were examined under a dissection microscope at x3 to x17.5.

Macerated cervical, thoracic and lumbar vertebræ, representing at least 10 normal canine skeletons, were also examined.

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The following human material was examined: 72 vertebræ, selected equally from the cervical, thoracic and lumbar regions and representing approximately 10 skeletons; a dissection of the dorsal and ventral longitudinal ligaments; part of a vertebral column cut in a sagittal plane to show the discs.

Anatomy of the Adult Canine Disc

The vertebræ. Normally there are 27 vertebræ cranial to the sacrum. There is no disc between the bodies of the first two cervical vertebræ, the joint here being diarthrodial; from the second cervical vertebra to the first sacral segment the bodies are separated by intervertebral discs, which total 26. This figure will vary, however, with the occasional fluctuations in the number of thoracic and lumbar vertebræ (see Sisson, 1953, p. 189). The coccygeal vertebræ also possess discs.

The articular surfaces of the vertebral epiphyses are of special importance, since they determine the shapes of the intervertebral discs. For this reason they may be capable of endowing any given disc with stable or unstable characteristics, factors which are the subject of our further investigations. Textbooks of canine anatomy tend to oversimplify the shapes of the epiphyses. In their general account of the vertebral bodies, Baum and Zietzschmann (1936, p. 5) and Miller (1952, p. 14) give the impression that the cranial and caudal epiphyseal surfaces have fundamentally different shapes, the former being convex and the latter concave. Examination of the bones and of radiographs has revealed a different picture. All the vertebræ cranial to the sacrum, even the cervical (except atlas and axis), show a central depressed area of substantial size, not only on the caudal epiphyseal surface but on the cranial also. Further, the caudal surface is always partly convex round its periphery. In fact, often the two surfaces are nearly identical. These various features can be seen on the lumbar vertebræ in plates 2A, 2B and 4A. The epiphyseal contours may be expressed in summary by the diagrammatic median vertical section in Fig. 2.

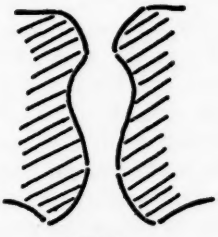

FIG.2

Diagrammatic median vertical section of a typical intervertebral space of the dog, to show the similar undulating conformation of cranial and caudal epiphyseal surfaces.

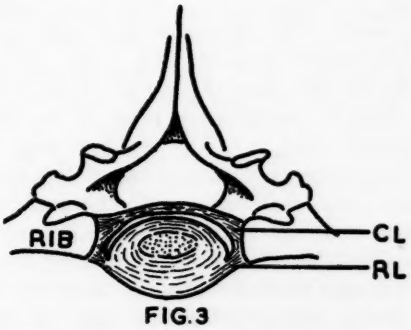

FIG.3

Semi-diagrammatic transverse section of a mid-thoracic disc of the dog, to show the conjugal ligament (CL) and the radiate ligament (RL). The dorsal longitudinal ligament and the attachments of the radiate ligament to the vertebræ are not shown.

Hansen (1952) has shown that hyaline cartilage covers the depressed central area of the epiphyseal surface (see Fig. 7A) to form the cartilage plate. It separates the nucleus pulposus and the inner layer of the annulus fibrosus from the bone of the epiphysis. We have been able to confirm the presence of the cartilage plate and its relationship to the nucleus pulposus. The plate is exceedingly thin.

The disc as a whole. Each consists of an outer fibrous ring, the annulus fibrosus, and a soft inner area, the nucleus pulposus, which is dorsally eccentric in position (Plate 1 and Fig. 1). Seen from a cranial (or caudal) view the discs are approximately oval in outline, the transverse diameter being the greater; the outline of the nucleus pulposus repeats that of the disc. Each disc fits the ends of the two adjacent vertebræ, which therefore impose on the disc its precise shape. From the cranial (or caudal) view the cervical discs are more nearly circular, the majority of the thoracic are a symmetrical oval, and the lumbar are bean-shaped (compare Figs. 1 and 3). In principle the conformation of the cranial and caudal face of any one disc is the same, and moreover it is constant throughout the cervical, thoracic and lumbar regions. There is a boss at the centre and the periphery expands progressively (in its cranio-caudal thickness) towards the rim (see the vertical median section, Fig. 7A). The disc thus somewhat resembles a car wheel of the solid variety.

Hansen (1952) estimated that the annulus fibrosus is about twice as wide ventrally as dorsally, and Miller (1952, p. 300) that it is nearly three times as wide ventrally. We have found ratios of dorsal to ventral annulus ranging from 1 : 1.5 to 1 : 2.8. Hansen (1952) found "vascular canals" in the discs of young dogs, but implied that he believed the adult disc to be avascular, nutrition being by diffusion. He was also unable to find any nervous elements in the disc, using the Palmgren method.

Ligaments. Four ligaments have intimate connections with the disc. The ventral longitudinal ligament (Fig. 1) is a strong band attached ventrally along the vertebral bodies from the sacrum to approximately the mid-thoracic region; it may occur in rudimentary form as far cranially as the atlas (Baum and Zietzschmann, 1936, p. 17). Neither these authors, nor Bradley (1948), nor Miller (1952), mention connections of this ligament with the discs. We have constantly found that fusion with the annulus fibrosus is in fact strong and extensive at every disc under which the ligament passes. The dorsal longitudinal ligament (Fig. 1) is attached dorsally along the vertebral bodies from the axis to the sacrum and continues into the coccygeal region as far as the neural arch persists (Baum and Zietzschmann, 1936, p. 18). It expands as it crosses each intervertebral space (Bradley, 1948, p. 287, and Miller, 1952, p. 300). Baum and Zietzschmann (1936, p. 18) and Miller (1952, p. 300) also give the important information that it fuses with the annulus fibrosus. We have confirmed the attachment from axis to sacrum, the occurrence of intervertebral expansions, and the blending with the annulus fibrosus of each disc over which is passes.

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The two remaining ligaments associated with the disc are the radiate and the conjugal (Fig. 3). The former runs from the ventral edge of the articular head of each rib to the annulus fibrosus and the two adjacent vertebræ (Baum and Zietzschmann, 1936, p. 21). The conjugal ligament is a strong, rather flattened band which runs dorsally across the disc between the heads of two corresponding ribs (Baum and Zietzschmann, 1936. p. 21). It is regularly absent from the first, eleventh, twelfth, and thirteenth ribs. According to Hansen (1952) it is also absent from the tenth rib, but Baum and Zietzschmann (1936) show it in their Fig. 23 between the tenth ribs. Our own observations indicate that its absence from the tenth rib is unusual.

The nucleus pulposus. The macroscopic and microscopic structure of the nucleus pulposus has been described by Hansen (1952) as follows. In the young normal adult of the non-chondrodystrophoid breeds the nucleus is a clear gelatinous substance; Baum and Zietzschmann (1936, p. 20) add that it has a slightly bluish sheen. Histologically it consists of a syncitium of comparatively undifferentiated mesodermal cells in a homogenous basophilic intercellular material. From the age of 1 to 7 years this mucoid consistency generally persists. The macroscopic appearance changes gradually, however, to greyish or milky white; dehydration is also evident. Histologically, collagenization slowly occurs. Eventually the nucleus pulposus becomes fibroid rather than mucoid. Beyond the age of 7 there are often small degenerative necrotic foci; in old age this degeneration becomes common. Calcification may occur, but only rarely. In the chondrodystrophoid breeds all these changes are greatly accentuated both in rate of occurrence and in degree. The frontier between the annulus fibrosus and the nucleus pulposus, which is never really distinct at any time, becomes progressively more blurred with the increasing fibrosis. We have confirmed the macroscopic changes in the appearance of the nucleus pulposus, and the loss of definition of the frontier between the nucleus and annulus.

The ability of the nucleus pulposus to bulge outwards from a fresh section of a disc is regarded as one of its characteristics (Miller, 1952, p. 14). This turgescence is ascribed to the nucleus pulposus being under constant pressure. Hansen (1952) stated that it is under considerable pressure at birth. Keyes and Compere (1932) noted that if the annulus fibrosus was cut in the living dog the nucleus pulposus exuded "obviously under considerable pressure." We have observed turgescence in our longitudinal sections of the vertebral column.

The annulus fibrosus. Hansen (1952) has described as follows the basic histological structure, and its changes with increasing age. In the normal young adult there is an inner fibro-cartilaginous and an outer fibrous layer. The outer layer consists in principle of concentric circular fibrous lamellæ, arranged one within the other and cemented together by an interlamellar substance. As the animal ages there is a tendency to degeneration, both of the interlamellar substance and of the lamellæ themselves. The former change leads to loosening of adjacent lamellæ, while the latter may result in a hyaline degeneration, with swelling, homogenisation, and fragmentation, of the collagen bundles. It is

noteworthy that these changes occur more readily in the dorsal part of the annulus.

The detailed structure of the lamellæ is founded on the direction taken by the component fibres. Each lamella consists of fibres running diagonally between two vertebræ (Baum and Zietzschmann, 1936, p. 19, and Hansen, 1952) (Fig.

FIG. 4

Lateral view diagram of a typical canine disc, to show the fibres of the outermost lamella running between the two vertebræ.

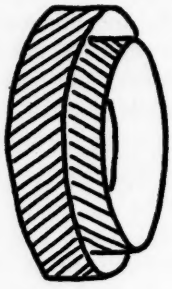

FIG. 5

Diagram of two adjacent lamellæ of a canine disc, showing the alternating obliqueness of the fibres.

4). These fibres run on into the bone itself, where they are considered by Hansen (1952) to be a continuation of Sharpey's fibres. As stated above, the most superficial lamellæ also blend with the dorsal and ventral longitudinal ligaments. We have confirmed the attachment of the fibres to both the bone and the ligaments. The fibres of adjacent lamellæ run in opposite directions (Fig. 5). In a cross section of a disc this alternation in the direction of fibres causes a varying reflection of light, so that the lamellæ appear as alternating light and dark rings (Plate 1). The caudal (or cranial) angle formed by fibres of two adjacent lamellæ in crossing each other is estimated by Baum and Zietzschmann (1936, p. 19) and Hansen (1952) at about 100° to 120°. Baum and Zietzschmann (1936, p. 20) also note that in the deeper zones of the annulus the fibres become more sagittal. Our findings agree with an angle of about 120° for the outer lamellæ, and indicate that the angle in the deeper zones is reduced to about 80° or 90°. The number of lamellæ in a disc is estimated by Hansen (1952) at between 10 and 30. Our observations have shown that the number commonly ranges between 25 and 35 (Plate 1), but occasionally reaches 40. Although the lamellar architecture consists basically of this system of alternating concentric rings, we have observed that dividing and blending of adjacent lamellæ is common (Plate 1). We have been unable to establish by simple dissection the details of these features in the dog, and so far as we know there is no published account of them.

Baum and Zietzschmann (1936, p. 20) have interpreted the functional value of the lamellar pattern. A rotation of the vertebræ will be resisted by alternating

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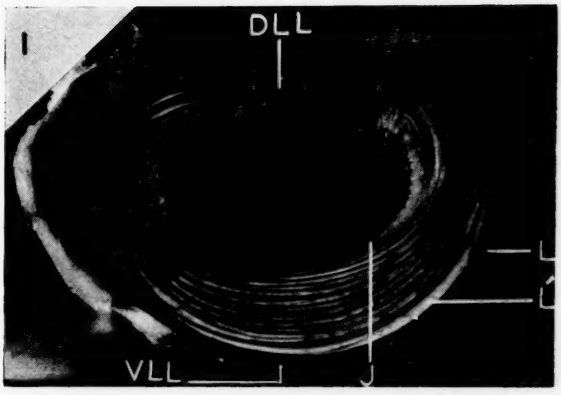

PLATE I

Mid-lumbar disc of young adult greyhound. Animal preserved with phenol-formalin fixative. Original dorso-ventral height of disc, 1.3 cm. Ratio of dorsal to ventral part of annulus fibrosus, including longitudinal ligaments, approximately 1 : 1.6. In the lumbar region both the disc and its nucleus pulposus are typically bean-shaped. The nucleus is quite translucent and makes a relatively distinct junction (J) with the annulus, characteristic of the young healthy disc. Some 30 lamellæ can be counted ventrally. Two giant lamellæ (LL′) form the lateral wall of each side of the disc. Dividing and blending of several lamellæ can be seen, especially ventrally. DLL = dorsal longitudinal ligament. VLL = ventral longitudinal ligament.

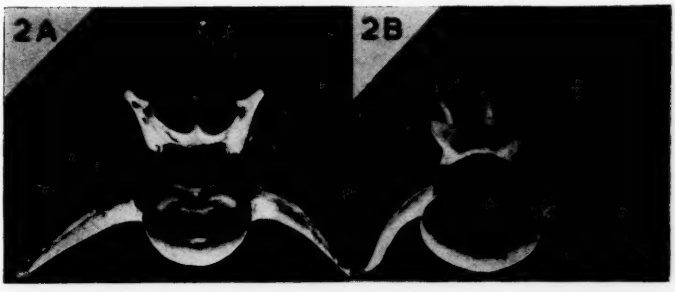

PLATE II

Mid-lumbar vertebra of dog. A cranial, B caudal epiphyseal surface. The two surfaces are similar, each with a central depression and a peripheral convexity.

(*Article by King and Smith, page* 135)

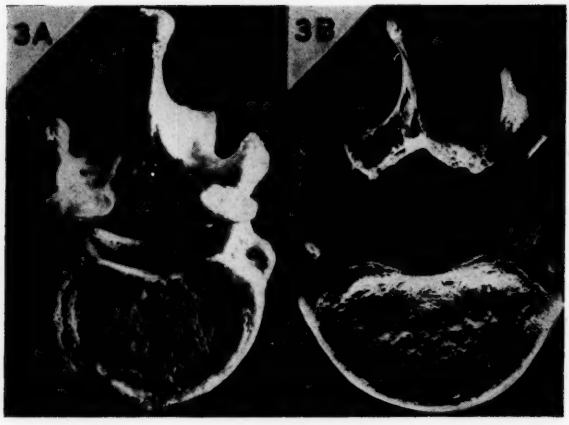

PLATE III

Caudal thoracic vertebra of man. A cranial, B caudal epiphyseal surface, each showing a flat central area completely surrounded by a narrow bony rim. (The two holes in the epiphysis of 3A are artefacts.)

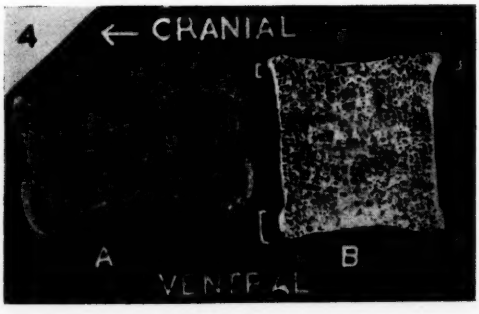

PLATE IV

Median vertical sections of A, a canine mid-lumbar and B, a human caudal thoracic vertebra. A shows the close similarity of the two epiphyseal surfaces with central depression and peripheral convexity. B shows the flat epiphyseal surfaces each with a bony rim (bracketed) which is complete dorsally as well as ventrally.

(*Article by King and Smith, page* 135)

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lamellæ. Curvature of the vertebral column will be resisted by the fibres lying in that side of the disc opposite to the flexion, the cruciform arrangement providing more elasticity than would a system of straight fibres. Hansen (1952) has analysed the functional inter-relation of the annulus fibrosus and nucleus pulposus. He concluded that this arrangement of a virtually fluid nucleus and a circular elastic annulus absorbs the shock of cranio-caudal compression; secondly that, in the event of compression of only a part of the disc as in spinal curvature, it distributes the pressure uniformly throughout the disc.

Disc length and vertebral mobility. From first principles it might be expected that a long disc (cranio-caudally) between two freely movable vertebræ would be more liable to herniation of the nucleus pulposus than a short disc between relatively immobile vertebræ, and in fact this concept has been applied in man by Bradford and Spurling (1945, p. 135). It is therefore desirable to know the relationship between the lengths of the discs and mobility in the cervical, thoracic, and lumbar regions.

According to Hansen (1952) the cranio-caudal length of the discs is greatest in the cervical region as a whole, though the lumbo-sacral is the longest individual disc. Those from the seventh cervical to the ninth thoracic vertebra are the shortest. Caudal to the ninth thoracic vertebra they increase progressively up to the lumbar region, where over-all they then remain rather constant. Baum and Zietzschmann (1936, p. 19) agree closely with this. Miller (1952, p. 300) gives the lumbo-sacral disc as the largest; he disagrees with the others, however, in stating that the discs decrease in all dimensions as they are traced cranially from the lumbo-sacral junction. Our own observations show that the cervical are the longest discs, the thoracic the shortest, and the lumbar intermediate, and thus confirm the views of Baum and Zietzschmann and Hansen.

The relative mobility of the different regions of the vertebral column of the dog does not appear to be precisely established. Slijper (1946) made some generalisations based on "a small number" of experiments "made with very different methods." He implied that the mobility of the cervical region, especially caudally, and of the lumbo-sacral junction is great. In the trunk the region round the tenth thoracic (the "diaphragmatic" vertebra) is the most mobile; cranial to this, mobility is slightly less and caudal to it much less (excluding the lumbo-sacral junction); these statements are deduced from Slijper's table 4. Reuter (1933), using methods similar to ours, found only a slight difference between cervical and thoracic mobility, while lumbar mobility was very much less; the main deficiency in thoracic movement, as compared to cervical, was in ventral flexion. Unlike Slijper (1946), she found that the thoracic region was most mobile in the cranial part of its middle section. Hansen (1952) appeared to regard the late thoracic area as a most important centre of movement, on the basis of Slijper's work. Lindemann and Kuhlendahl (1953), probably through an over-simplification of Hansen's view, state that the thoraco-lumbar junction is the most mobile part. Baum and Zietzschmann (1936, p. 19), in contrast to

the other authors, indicate indirectly that the cervical and lumbar regions are more mobile than the thoracic. Our own observations, made by methods we admit to be far too subjective, show that the cervical region is much the most mobile and the lumbar the least, that the cranial half of the thoracic region is only slightly less mobile than the cervical, and that the caudal half of the thoracic region is only slightly more mobile than the lumbar; the lumbo-sacral disc is very mobile. This agrees with Reuter (1933) but disagrees with Slijper (1946) in indicating that thoracic mobility resides more in the cranial half of the region than in the vicinity of the diaphragmatic vertebra.

It therefore appears that the relationships of disc length to vertebral mobility are probably as follows: in the cervical region both disc length and mobility are maximal; in the thoracic region disc length is minimal and mobility is intermediate; in the lumbar region disc length is intermediate and mobility is minimal.

The Adult Human Disc: Comparison with the Dog

The vertebræ. Normally there are only 23 discs from the second cervical vertebra to the sacrum, the thoracic vertebræ being one less and the lumbar two less than in the dog (see Gray, 1949, p. 216); there are no coccygeal discs, although the sacro-coccygeal junction is effected by fibro-cartilage (Gray, 1949, p. 449).

The articular surfaces of the adult vertebral bodies are very different from those of the dog (Plates 2, 3 and 4). Firstly, as a general rule the lateral view profile is straight rather than undulating. (The cervical vertebræ differ in being transversely very concave cranially and slightly convex caudally; vertically they are straight or slightly concave.) Secondly, the periphery has a distinct bony rim, which is present from the axis to the sacrum but is less pronounced in the cervical vertebræ; histologically it is compact bone (Beadle, 1931). Joplin (1935) described this rim as 2 to 3 mm. wide and 1.5 to 2 mm. high; he also stated that it is absent dorsally, and believed this to be an important factor in dorsal herniation of the nucleus pulposus. Bradford and Spurling (1945, p. 18) describe the rim as "defective" dorsally. Bick and Capel (1951) were more guarded in remarking that it "may be lacking" dorsally. Calvé and Galland (1930), on the other hand, made no reference to its absence dorsally and in fact expressly implied that it is distinct in that region. Beadle (1931), also, described the rim as narrower but higher dorsally. It is noteworthy that Calvé and Galland, and Beadle, had the advantage of access to Schmorl's collection of specimens, which is commonly acknowledged to be without equal in number, quality and variety. Our own observations on 72 vertebræ of all regions showed that in 80 per cent the rim was present dorsally, being often reduced in width but not in height (the vertebra in Plate 3A is typical); in the remainder it was absent or reduced in height. From this and the literature we conclude that in the average vertebra the ring is complete, as in Plates 3A, 3B and 4B.

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The cartilage plate is "countersunk" into the end of the vertebra (Collins, 1949, p. 258), to assume the relationships shown in Fig. 7B.

The disc as a whole. The general outline of the disc and its components, as seen from a cranial (or caudal) view, resembles that of the dog. But owing to the entirely different contours of the articular surfaces of the vertebral bodies

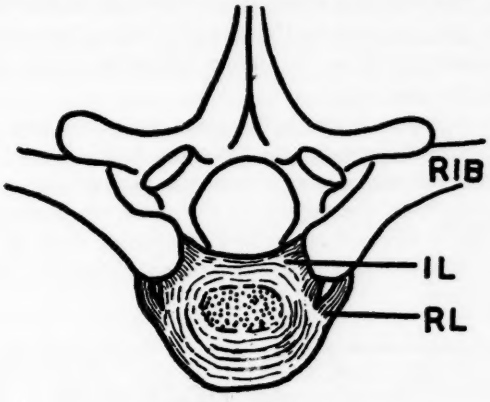

FIG. 6

Semi-diagrammatic transverse section of a mid-thoracic disc of man, to show the intra-articular ligament (IL) and radiate ligament (RL). (After Gray [1949], Fig. 505). The attachments of the two ligaments to the vertebræ are not shown.

the detailed conformation is markedly dissimilar. The disc is flat like a coin, except that both faces are indented around the periphery by the bony rims of the vertebræ (see Fig. 7B).

Although various authors (Joplin, 1935, Collins, 1949, p. 261) have emphasised its importance, no figures have been found for the ratio of thickness of the ventral to the dorsal part of the annulus. However, from published photographs (e.g., Figs. 1 and 2 of Beadle, 1931) it appears that as in the dog the ratio is about 2 to 1.

Keyes and Compere (1932) and others found that the adult disc was avascular, and Collins (1949, p. 256) reaffirms this view. Peacock (1952) observed small vessels in the annulus, but believed the nucleus pulposus to be avascular throughout life. Coventry *et al.* (1945*b*) saw vascularisation of the annulus from the fourth decade onwards. It seems safe to conclude that in both dog and man the nucleus pulposus is avascular and the annulus fibrosus is at the most only slightly vascular. Jung and Brunschwig (1932) and most other workers were unable to find nerve elements in the disc. More recently Roofe (1940), using a Bodian technique and Garven's gold chloride method, succeeded in finding numerous nerve endings. Comparison with the dog is difficult since although Hansen (1952) failed to find these elements he did not apply Roofe's techniques.

Ligaments. The ventral and dorsal longitudinal ligaments in general resemble those of the dog. There is no doubt that both of them blend with the intervertebral discs (Gray, 1949, pp. 444, 445), and it is further claimed that the fusion is much stronger ventrally than dorsally (Coventry *et al.*, 1945*a*, Peacock, 1952); the dorsal ligament has typical intervertebral expansions (Grant, 1951, Fig. 366). The terminal attachments, however, differ from the dog: the ventral ligament does not end in the thoracic region but extends to the skull, and the dorsal ligament ends on the sacrum instead of on the coccygeal vertebræ (see Gray, 1949, pp. 444, 445).

The radiate ligament is much the same as in the dog (see Gray, 1949, p. 456). The conjugal ligament, on the other hand, is very different. Gray (1949, p. 456) indicates that it is represented in man by the intra-articular ligament, which occurs from the second to the ninth rib inclusive. Comparison of Fig. 6 with Fig. 3 shows that, instead of crossing over the disc to join the opposite rib, the intra-articular ligament attaches directly to the disc and to the two adjacent vertebræ.

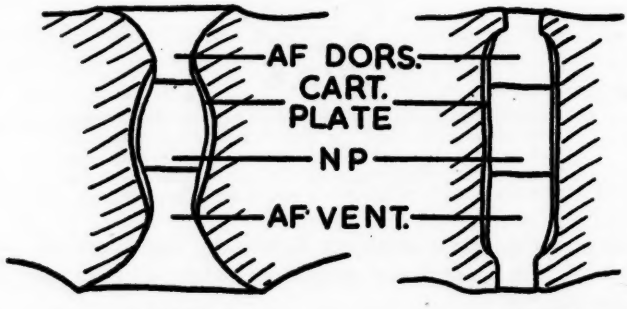

FIG. 7A FIG. 7B

Diagrammatic median vertical sections of A, a typical canine disc, and B, a typical humah disc, showing the relationship of the ventral and dorsal parts of the annulus fibrosus (AF vent. and AF dors. respectively) and the nucleus pulposus (NP) to the epiphyseal contours and to the cartilage plate (cart. plate).

The nucleus pulposus. From the account of the nucleus pulposus by Coventry, *et al.* (1945*b*) it is evident that in nearly all respects it is very similar in the normal adult man and dog. Thus there is an initial meshwork of mesodermal cells, the macroscopic appearance being translucent and gelatinous. During the third decade the nucleus is no longer mucoid in appearance. Heavy fibres appear. In the fourth decade the replacement of the nucleus with fibrous tissue is very evident; Peacock (1952) noted that the nucleus is now no longer translucent but whitish and of firmer consistency. The frontier between annulus and nucleus has become steadily more indistinct. Dehydration is progressive. After the fourth decade the fibrous tissue begins to change into fibro-cartilage, the process being completed by about the sixth decade. Focal and diffuse

necrosis are evident in the fifth decade and onwards. Calcification occurs, though rarely (Keyes and Compere, 1932). Thus from the end of adolescence to senility the nucleus pulposus follows the same pattern of changes as in the dog. The one outstanding difference is that in man the fibroid phase, which is the ultimate one in the dog, is eventually entirely superseded by one of fibro-cartilage.

Turgescence has been the subject of much discussion and some experiment. Collins (1949, p. 261) discusses experiments which show that bulging occurs from sectioned discs even when all forces due to muscles and weight-bearing are eliminated. Experiments conducted by Petter (1933) indicate that in a fresh cadaver this pressure is about 30 lb. It seems likely that the phenomenon is identical in principle in dog and man.

The annulus fibrosus. It is difficult to find any significant differences between the two species. There is the same initial division into an outer fibrous and an inner fibro-cartilage layer (Peacock, 1952). Coventry, *et al.* (1945*b*) gave a comprehensive description of the annulus and its maturation changes. All the phenomena of aging observed by Hansen (1952) in the dog occur between the third and sixth decade, namely, loosening of the lamellæ, homogenisation, swelling of fibres, and fragmentation. Also the dorsal part of the annulus is again the more affected. The only difference is that vascular invasion of the annulus is claimed from the fourth decade, but other authorities believe the disc to be avascular (see above).

The architecture of the annulus is practically identical. There are concentric lamellæ of diagonal fibres, which alternate in direction in adjacent lamellæ and attach to the vertebræ and their ligaments (Gray, 1949, pp. 445, 446, Peacock, 1952). Rouviere (1921) estimated the angle at which the fibres cross to be about 100° to 120°. The number of lamellæ in the annulus is seldom stated, presumably because of the uncertainty of counting the thin inner lamellæ. Joplin (1935) observed 10 to 12 very stout lamellæ in a lumbar disc. The detailed complications of architecture such as blending and dividing of adjacent lamellæ, which we observed in the dog, have been the subject of extensive research in man; at least one worker, using polarised light, has found in them a factor influencing disc protrusion (see Peacock [1952] for discussion).

Disc length and vertebral mobility. Although the figures are not given, Bradford and Spurling (1941, p. 15) state that the cervical and lumbar discs have a greater cranio-caudal length than the thoracic. Collins (1949, p. 256) adds that the lumbar discs are the longest of all. Hence there is some similarity to the dog, in that the thoracic discs are the shortest.

Bradford and Spurling (1945, p. 15) and Gray (1949, p. 446) make it clear that mobility is greatest in the cervical and lumbar regions.

The relationship between disc length and vertebral mobility, therefore, differs in man. Here the thoracic region combines minimum disc length with minimum mobility while the cervical and lumbar regions associate greater disc length with greater mobility.

Discussion

The anatomical differences between the canine and human disc. The articular surfaces of the vertebral bodies present outstanding differences. They have little in common in the two species, differing both in general contour and in the special feature of the bony rim of man.

The general outline of the disc, from the cranial view, is much the same in both species. On the other hand, the conformation of its faces shows fundamental differences corresponding to the differences in the surfaces of the vertebral bodies, the human disc being coin-like with a narrow rim, and the canine disc being wheel-like with a central boss and a greatly expanded rim. It remains uncertain whether the vascular and nerve supplies are identical, since there is disagreement among human anatomists and a lack of technical studies in the dog.

Except for the conjugal (intra-articular) ligament the ligaments associated with the disc are closely similar. The only definite differences in the longitudinal ligaments lie in the extreme cranial and caudal attachments. Of these the variations in the dorsal ligament affect only the coccygeal vertebræ. A more substantial difference is that the ventral longitudinal ligament of man extends along the cervical vertebræ, where in the dog it is at the most only vestigial. The radiate ligament is virtually identical.

The conjugal ligament is very different from the intra-articular ligament. In the dog it is a relatively massive structure which, by its close contact with the annulus fibrosus, is likely to give the intervertebral disc powerful support dorsally. In man the intra-articular ligament attaches directly to the disc itself and therefore does not support the disc dorsally.

The nucleus pulposus is similar in all but the final modification of structure with age. In the dog the fibroid nucleus is the ultimate stage but in man this is superseded by one of fibro-cartilage. There are no significant differences in the annulus fibrosus.

The relationship between disc length and vertebral mobility is similar in both species in the cervical region, where substantial disc length is combined with great mobility. In the thoracic and lumbar regions, however, it differs. In the former both species have small disc length, but mobility, while small in man, is moderately great in the dog. In the lumbar region disc length is great in both species but mobility is great in man and minimal in the dog.

It is thus clear that in many respects the anatomy of the disc is virtually identical in man and dog. There are, however, at least five outstanding differences, which concern the contours of the articular surfaces of the vertebral bodies, the corresponding contours of the surfaces of the disc, the conjugal as opposed to the intra-articular ligament, the final maturation change in the nucleus pulposus, and the relationship between disc length and vertebral mobility in the thoracic and lumbar regions. It is therefore evident that Lob's (1933) assertion, made on the basis of his anatomical observations on the rabbit, that "the disc of the quadruped is not different in structure and function from that of man" requires considerable qualification.

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The possible influence of these anatomical differences on herniation of the nucleus pulposus. So similar are the intervertebral discs in the two species that the occurrence of similar disease processes may be anticipated. The possibility is also to be anticipated, however, that those outstanding anatomical differences which do exist may modify the pathogenesis of these conditions, and this will now be briefly considered.

The differences in the contours of the articular surfaces and the concomitant differences in the shape of the disc could have repercussions on the mechanism of dorsal and ventral herniations of the nucleus pulposus. The bony rim of the average human vertebra supports the whole periphery of the disc: the expanded rim of the canine disc on the other hand receives much less support from the curving vertebral surfaces (compare Fig. 7B with Fig. 7A). Consequently the canine disc may be the more vulnerable to these herniations.

The differences between the conjugal and intra-articular ligaments are likely to affect dorsal herniations. The support given to the dorsal annulus by this powerful ligament might well severely restrict dorsal herniation in the dog. This possibility has been suggested by Hansen (1952) and Hoerlein (1953). These workers have, in fact, demonstrated that herniations into the neural canal are negligible in incidence throughout the thoracic discs where the ligament is present: in contrast there is evidence that in man dorsal protrusion may be nearly as common throughout the thoracic region as elsewhere (see Collins, 1949, pp. 265-266). Only for the discs where the conjugal ligament is present is there some foundation for Boddie's view that disc prolapse in a manner comparable to that seen in man is anatomically impossible in the dog, but even with these discs dorsal protrusion does occasionally occur (Hansen, 1952).

The more extreme maturation change, to fibro-cartilage, of the human nucleus pulposus presumably predisposes man more than the dog to all types of herniations, i.e., cranial and caudal (Schmorl's nodes), as well as dorsal and ventral herniation. However, it cannot be assumed conversely that the arrest of these changes at the fibroid stage in the dog should grant this species substantial protection against herniation. The healthy nucleus pulposus functions correctly only because of its fluid-like properties, and these are lost with fibrosis.

The differences in disc length and vertebral mobility could conceivably influence the regional distribution of dorsal and ventral herniations. Although the disc length is similar in the two species, the relatively greater mobility of the thoracic region in the dog might predispose to herniation in this region (though the conjugal ligament must be taken into account in respect of dorsal herniation): the same predisposition applies to the lumbar region of man.

Finally, it is necessary to take into account posture. It could be argued that the upright stance of man is more favourable to herniation of the nucleus pulposus than the horizontal posture of the dog. Splithoff (1946) wrote: " When man assumed the upright posture he not only set himself apart from the animal kingdom, but he also set the stage for a series of disorders of the low back which have plagued him since." As herniation of the nucleus pulposus is the commonest cause of this type of disorder (see Burns, 1951), Splithoff's remark

appears to indict the vertical posture as a prime factor in inducing herniation. There is certainly little doubt that the upright posture can be used to impose strains on the discs which they cannot withstand. Thus Bradford and Spurling (1945, p. 72), in an analysis of mechanical and postural factors influencing lumbar herniation, remark that the commonest activating cause is lifting a heavy object in a bent-forward position. They calculate that a man lifting a 100 lb. weight with arms outstretched submits his lumbo-sacral disc to a force of 1,600 lb. or more. These considerations prove that certain parts of the human vertebral column are especially vulnerable, but they do not show that there are no stresses and strains inherent in a horizontal posture. A physical analysis of forces on the thoracic and lumbar discs in the turning, braking and leaping dog is the only way to determine accurately the dangers that exist in the horizontal posture. In the absence of such precise information only rough generalisations can be made. It is to be expected that the regions in which the stresses and strains on the disc will be greatest will vary with the two postures. Thus, one might anticipate lesions of the caudal lumbar discs to be less common in the dog than in man, since the dog does not expose those discs to the same hazards of weight. On the other hand, the middle of the arch of the horizontal vertebral column, especially where there are no ribs to give extra support, appears particularly vulnerable. In fact, in man dorsal herniation of the nucleus pulposus is as common in the last lumbar discs as in any other site (see Collins, 1949, p. 265), whereas in the dog it is substantially less common there than in the region of the lumbo-thoracic junction (Hoerlein, 1953). However, although posture is likely so to affect the details, it seems unlikely to cause the basic characteristics of herniations of the nucleus pulposus to differ in the two species.

Summary

1. Macroscopic observations have been made on the intervertebral discs, the vertebral epiphyseal surfaces, and the conjugal and longitudinal ligaments of the dog. These have been incorporated into a general account of the macro- and microscopic anatomy of the canine disc and its associated structures.

2. The human disc and associated structures have been compared.

3. It has been found that in many respects the anatomy of the disc is virtually identical in dog and man. There are, however, five outstanding differences which concern: (1) the contours of the articular surfaces of the vertebral bodies; (2) the conformation of the surfaces of the disc; (3) the conjugal and intra-articular ligaments; (4) the final histological maturation change in the nucleus pulposus; (5) the relationship between disc length and vertebral mobility in the thoracic and lumbar regions.

(4) The possible influence of these anatomical differences and of posture on herniation of the nucleus pulposus has been discussed.

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THE DESTRUCTION OF DAY-OLD CHICKS

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OWING to the demand for female chicks being usually greater than that for males, hatcheries may have as many as 10,000 day-old cockerels surplus to requirements which have to be destroyed. It is felt that in some instances lack of knowledge of the availability of efficient humane methods of destroying chicks has resulted in chicks being destroyed by such methods as drowning and smothering, in which needless suffering is caused.

The humane destruction of animals, other than chicks, has already been dealt with in considerable detail (N.V.M.A., 1937). The destruction of chicks, however, involves certain aspects which are absent from normal animal destruction which call for special attention. One of these is the necessity to kill large numbers at one time owing to the number surplus to requirements not being known until the end of the day, after the complete hatch has been sexed. Another aspect is the economic one which makes it necessary for the method used to require a minimum amount of labour, require comparatively inexpensive apparatus and materials, and be sufficiently safe and simple to be undertaken by unskilled operators.

The most suitable method for mass destruction, which is already in use in the majority of the better equipped hatcheries in this country, is gassing in lethal chambers. The present investigation consists of a survey of a number of lethal gases and vapours, and is aimed at determining their relative suitability for destroying chicks in lethal chambers from both a humane and a practical viewpoint. It is hoped that the information which is presented herewith will be of some help to those concerned with the problem of chick destruction.

There are a large number of lethal gases and vapours in existence, but because the majority of these are either dangerous to handle, highly inflammable, limited in supply or expensive, only a few have a practical application. Of these, three are in use at the moment—coal gas, petrol engine exhaust gases, and carbon tetrachloride. Each of these, however, has certain drawbacks. Although not as dangerous to handle as Cymag or hydrocyanic acid, they are all sufficiently toxic and unpleasant to the person operating the lethal chamber to necessitate the chamber being sited out of doors, or being fitted with a ventilating system. Coal gas has the additional disadvantage of being inflammable, and is unsuitable for universal use as it is often unavailable in rural areas. For this reason, tests were made with carbon dioxide as this gas does not suffer from any of these disadvantages, and although not having been used up to the present for lethal purposes its use has been established in the U.S.A. for the anæsthetisation of pigs prior to slaughter.

The use of chloroform was examined as an alternative to carbon tetrachloride because of its established use in animal euthanasia. The use of butane

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(Calor gas) was examined as an alternative to coal gas owing to its ready availability. Tests were also made on the lethal action of nitrogen and carbon monoxide so that information could be gained on the contribution these gases make towards the lethal action of exhaust gases.

Experimental Methods

Tests were made in a special design of lethal chamber and in a large size R.S.P.C.A. box. In some cases, where the gas was difficult to obtain in large quantities or was inflammable, tests were made on individual chicks in 2 lb. Kilner jars. In these cases a minimum of five chicks were used for each concentration of gas used. The lethal chamber was constructed large enough to accommodate two 25-size chick boxes, each of which, with the internal fittings removed, was capable of holding 50 chicks. Tests with this chamber were made using 25 to 50 chicks. The internal dimensions of the chamber were 20 in. x 15.5 in. x 5.6 in., and in capacity and accommodation was approximately equivalent to a small size R.S.P.C.A. box. The top of the chamber, and the lids of the chick boxes inside, were made of Perspex to facilitate observation of the chicks. The front of the chamber was sealed by a rubber-edged door. The gas inlet was situated at the side near the base of the chamber. In the tests, $\frac{1}{4}$ in. tubing was used to admit carbon dioxide and nitrogen, and $1\frac{1}{4}$ in. tubing to admit exhaust gases. A ventilation port was made in the top of the chamber, which was opened or closed to suit the rate of entry of the gas used.

The R.S.P.C.A. box measured 17 in. x 17 in. x 30 in., and with the centre panel removed was capable of holding nine 25-size chick boxes, i.e., a maximum of 225 chicks. In the tests, a number of chicks were placed in each of the nine boxes so as to check the distribution of the gases and vapours used. The majority of the tests were made on chicks in boxes. These were not found to restrict the penetration of the gases to the chicks. All tests using gases were made at room temperature (20° C. approximately) with the exception of tests made with exhaust gases which were made out of doors at a slightly lower temperature. In the case of vapours, because of the influence of temperature on vapour concentration, tests were made at the maximum and minimum temperatures which would be experienced in practice.

A note was made in each test of the reactions of the chicks to the various lethal agents before and after unconsciousness, and also the times taken to produce unconsciousness and death.

(1) Nitrogen

The lethal action of this gas is due to the production of anoxia by asphyxiation.

Tests were made in the special chamber, 20 chicks for each test.

The violence of the convulsions which occurred before death did not appear

to be connected with the rate at which asphyxiation was produced. They were similar to the convulsions observed when chicks are killed by dislocation of the neck and are probably due to a reflex action. This view is strengthened by the observations made on the action of nitrogen on man by Alexander and Himwitch (1939), who consider that convulsive movements begin after loss of consciousness.

Table 1. The lethal action of nitrogen.

Rate of entry of gas cu.ft./ minute	Preanaesthetic stage		Postanaesthetic stage	
	Duration in seconds	Symptoms	Duration in seconds	Symptoms
1.5	60	No apprehension. Stupor produced before collapsing.	90 - 150	Weak respiratory movements for first 60 seconds, followed by violent convulsions for 30 seconds. Dead when removed one minute later.
0.75	180	As above	180	Weak respiratory movements for first 150 seconds, followed by violent convulsions for 30 seconds. Dead when removed one minute later.
4.5	25	Apprehension, indicated by struggling. No stupor produced before collapse.	30-90	Violent convulsions for first 30 seconds. Dead when removed one minute later.

The stupor that precedes unconsciousness when asphyxia is produced, is absent when asphyxiation is produced in a manner whereby the chicks are conscious of an unfavourable change taking place in their environment such as occurred in these tests when nitrogen was passed into the chamber at a high flow rate. This indicates the undesirability of any method of asphyxiation which does not induce anæsthesia, and which in some way alerts the chicks to the change in their environment, thus inducing a vigorous resistance to asphyxiation. This applies to asphyxiation by smothering and drowning. With the latter method struggling persists for at least 45 seconds before loss of consciousness.

(2) Carbon Monoxide

The lethal action of this gas is due to the production of anoxia, by anoxæmia alone if the gas is present in low concentrations, and by anoxæmia and asphyxia when the pure gas is used. Carbon monoxide combines firmly with the hæmoglobin of the blood and has no direct action on the central nervous system. In this respect it differs from carbon dioxide. The lethal action of carbon monoxide is therefore similar to nitrogen, its value as a lethal agent depends on the difficulty with which the anoxæmia it produces can be reversed, so that chicks removed prematurely, by accident, from the lethal chamber, in an unconscious state, would be unlikely to revive in contact with the air.

Tests were made in Kilner jars using varying concentrations of carbon monoxide.

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The production of anoxæmia appeared to be very rapid even with 5 per cent carbon monoxide. The convulsions began before the chicks collapsed and became comatose. They were approximately of the same duration and violence as those which occurred with nitrogen.

Table 2. The lethal action of carbon monoxide.

Concentration in air %	Preanaesthetic stage		Postanaesthetic stage	
	Duration in seconds	Symptoms	Duration in seconds	Symptoms
100	25-34	No immediate apprehension. After 9 seconds violent flapping of wings and convulsive movements culminating in collapse.	5	Spasmodic respirations. Viscera cherry red in colour.
75	39-43	As above, struggling commencing after 9-12 seconds.	5	As above.
50	22-31	As above, struggling commencing after 9-15 seconds.	5	As above.
15	32-49	As above, struggling commencing after 16-20 seconds.	5	As above.
5	61	As above, struggling commencing after 26 seconds.	5	As above

(3) Carbon Dioxide

The lethal action of this gas is due to the production of anoxia, by anoxæmia and asphyxia, and also from its narcotic effect. It differs from the action of carbon monoxide by being non-toxic in concentrations below 20 per cent in air, by having a depressant effect on the central nervous system, and in being reversed when chicks are removed from the gas, and exposed to the air, during the state of unconsciousness prior to death.

Carbon dioxide for the tests was obtained from a cylinder of the compressed gas. Initial tests made with solid carbon dioxide showed that the evolution of the gas from the solid form, without the use of elaborate apparatus, was too slow for it to be a practical source of gas for chick destruction purposes. The use of a pressure reducing valve on the cylinder was found necessary, as without it a considerable proportion of the escaping gas was converted to the solid form. A reducing valve fitted with a pressure gauge registering up to 50 lb./sq. in. with a fine adjustment valve was connected to the cylinder. The pressure reducing valve was adjusted to drop the pressure to 20 lb./sq. in., and by opening the fine adjustment valve one complete turn a standard flow of gas could be used for the tests. This approximated to a flow of 1.5 cu. ft. per minute. Samples of the

atmosphere in the chamber were taken during the tests to correlate the behaviour of the chicks with the carbon dioxide concentration. The tests were made in the special chamber using 30 chicks for each test.

It was found that 100 per cent mortality could be achieved if the gas was passed into the chamber for 1½ minutes, and the chicks were retained in the sealed chamber for a further 2½ minutes. The gas concentration was found to have fallen to 36 per cent by the end of this period as a result of diffusion through cracks in the chamber.

Table 3. The lethal action of carbon dioxide.

Rate of entry of gas cu.ft/minute.	Preanaesthetic stage		Postanaesthetic stage	
	Duration in seconds.	Symptoms.	Duration in seconds.	Symptoms.
1.5	30	Immediate awareness. Behaviour suggested mild irritation of eyes and mouth. Dyspnoea after 15 secs. at 48% CO_2, accompanied by stupor which was followed by collapse.	150 - 210	Very slow respiratory rate and shallow respirations making time of death difficult to determine. A few chicks showed slight convulsive movements but the majority showed none. CO_2 conc. at death 98%.
0.75	45	As above.	240	As above.

When the rate of entry of gas was lower than 1.5 cu. ft./minute the duration of the preanæsthetic period was increased. The same effect would be obtained with the gas entering at a rate of 1.5 cu. ft./minute and a larger chamber. This limits the size of the chamber which can be used with the gas if the preanæsthetic period is to be kept to minimum duration, as an increase in the entry rate of the gas above 1.5 cu. ft./minute, to compensate for increase in size of the chamber, is impractical, because of the freezing of the gas that was found to occur with higher flow rates.

The lethal action of carbon dioxide is characterised by the extremely rapid production of anæsthesia, a state of stupor being produced in the chicks after 15 seconds. This may be due to the rapid increase in the carbon dioxide content of the tissues resulting from the hyperventilation of the lungs associated with the dyspnœa. It is possible that the awareness of the chicks to the gas, and the dyspnœa which occurs before loss of consciousness, may subject them to some discomfort. The narcotic effect of the gas is shown by the relative absence of convulsions during the postanæsthetic stage.

Carbon dioxide was also found to suppress convulsive movements in certain tests made with carbon monoxide when carbon dioxide was present in a concentration of 25 per cent.

The reversibility of the narcosis produced by carbon dioxide when chicks are removed in an unconscious state from the chamber to the air, is a disadvantage in that particular care must be taken to keep the concentration of gas at a high level for at least five minutes. In some cases unconscious chicks showed no respiratory or other movements for as long as five minutes after removal from

the chamber, and then made a complete recovery in a few minutes. Chicks in the unconscious state showed no reflex contractions of the limbs when pressure was applied to their extremities.

Carbon dioxide has the advantages of being relatively inexpensive, and, in consequence of it being possible to liquefy it under pressure at normal temperatures, a 20 lb. cylinder is capable of holding a large volume of gas (240 cu. ft.), so that for a small hatchery the cylinder would require infrequent renewal. Its low toxicity in low concentrations is also advantageous in that the gassing procedure can be carried out inside the hatchery premises. It has, however, certain practical drawbacks in that the outlet valve of the cylinder tends to freeze up when the rate of flow exceeds 1½ cu. ft. per minute for more than three minutes. This restricts the size of the chambers used with the gas to about one cu. ft. capacity and, as the gas concentration has to be kept at a high level for at least five minutes, the chambers have also to be well sealed.

(4) Exhaust Gases

In the petrol engine, these gases consist approximately of 70 per cent nitrogen together with carbon monoxide, carbon dioxide and water vapour. The proportions of the two oxides of carbon vary according to the air/fuel ratio combusted in the engine. Under the correct air/fuel ratio for normal running (15 : 1), there is a negligible amount of carbon monoxide present and about 13 per cent of carbon dioxide. With a richer mixture (8 : 1), produced by the use of the choke, the carbon monoxide content rises to about 14 per cent and the carbon dioxide content is reduced to 5 per cent.

In a well-maintained diesel engine the air supply tends to be in excess of that required to combust the fuel. The composition of its exhaust gases will therefore be similar to that of the petrol engine using a high air/fuel ratio, and carbon monoxide will be absent.

The lethal action of exhaust gas is due to anoxia resulting from asphyxiation, which is produced principally by the nitrogen present, coupled with anoxæmia produced by carbon monoxide, when rich fuel mixtures are used, or by carbon dioxide when weak mixtures are used. When carbon dioxide is present, a degree of narcosis dependent on its concentration is produced. The pharmacological action of exhaust gases will also be affected by any unreacted hydrocarbon compounds which may be present. Exhaust gases do not include free oxygen unless the mixture is very weak, so that any variation that occurs in the air/fuel ratio is only likely to affect the lethal action by altering the relative proportions of carbon monoxide and carbon dioxide.

In the tests, exhaust gases were obtained direct by connecting the exhaust pipe to the chamber with flexible hose. The engines were run at minimal speed at different positions of the choke. Tests were made in the special chamber and the R.S.P.C.A. box using a minimum of 50 chicks per test.

No difference in symptoms was noticed when the mixture was richened by the use of the choke. The presence of muscular inco-ordination which preceded collapse suggested a neurotoxic action. The convulsions which occurred after loss of consciousness were less violent than those obtained when nitrogen was used, which indicates that a degree of narcosis was produced before death. The use of the engine choke to produce a high concentration of carbon monoxide

Table 4. The lethal action of exhaust gases.

Engine details	Chamber used.	Preanaesthetic stage		Postanaesthetic stage	
		Duration seconds	Symptoms	Duration seconds.	Symptoms
16 H.P. R.P.M. - No choke	Special	120	Awareness and fluttering. After one minute showed inco-ordination of movements until they collapsed 30 seconds later. Slight movements until unconscious.	30	Convulsions at intervals. Redness of muscle tissue usually absent in the majority of tests.
16 H.P. R.P.M. - Choke	Special	120	As above.	30	As above but redness of muscle tissue invariably present.
10 H.P. R.P.M. 400 approx. No choke.	Special	60	As above but collapsed after 15 seconds.	30	As above. Redness of muscle tissue absent.
10 H.P. R.P.M. 400 approx. No choke	RSPCA	90	As above but collapsed after 45 seconds.	30	As above.
3 H.P. R.P.M. - No choke	RSPCA	330	As above. Time of collapse uncertain.	30	As above.

has certain practical drawbacks. One is that the engine tends to stall and its efficiency is impaired when run under these conditions. Another is the production of soot, the particles of which are fine enough to pass through the usual filtering materials. A smoke such as this is likely to cause apprehension to the chicks and is therefore disadvantageous. It is considered better to adjust the choke until a smokeless exhaust is obtained. This will result in the production of both carbon dioxide and carbon monoxide. Increase in the concentration of the former will assist in the production of narcosis, and as long as some degree of choke is used sufficient carbon monoxide will be generated to ensure the production of a state of persistent anoxæmia.

Using engines started up from a cold condition with an outdoor chamber, the exhaust gases did not raise the temperature of the chamber above 82° F. With the R.S.P.C.A. box the highest temperature obtained was 80° F. It appears unlikely, considering the short duration of the gassing period, that undesirable temperatures above 100° F. would be reached when an outdoor chamber is used.

The long time before anæsthetisation was produced when the small egnine was used indicates that at least a four-cylindered water-cooled engine is necessary for the production of exhaust gases for destroying chicks. Two-stroke engines in particular are unsuitable owing to the amount of oil smoke in their exhaust gases.

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From these observations the following procedure can be recommended for the use of exhaust gases in chick destruction:—The gases should be generated by a water-cooled petrol engine in good running order which will not produce any oil fumes in the exhaust. The engine should be started from a cold condition and run at minimum speed with the choke closed as far as possible without producing sooty smoke. The gases should be led into the base of the chamber and the exit should be at least one foot above the top layer of chicks. A maximum recording thermometer should be included in the chamber, and if the temperature exceeds 100° F. then the exhaust gas must be cooled in a water-jacketed pipe before entry into the chamber. After the air has been displaced from the chamber the chicks must be exposed to the exhaust gases for a mimimum period of three minutes. The time taken to fill the chamber with exhaust gas will depend principally on the size of the engine and the speed at which it is run. The output of gases from an engine run at minimal speed, disengaged, can be obtained from the engine manufacturers and from this the time taken to fill the chamber with

Table 5. The lethal action of coal gas.

Gas concentration %	Preanaesthetic stage.		Postanaesthetic stage.	
	Duration seconds	Symptoms	Duration seconds	Symptoms
100	15–20	No awareness, stupor produced before collapsing.	55–70	Convulsions for first 30–40 seconds, followed by infrequent shallow respiratory movements.
50	45–50	As above.	195 – 205	Convulsions for the first 45 seconds followed by infrequent shallow respiratory movements.

gases can be calculated. The minimum duration of gassing will then be this time plus three minutes. In the case of the 10 H.P. Ford Popular engine, which was one of those used in the tests, 2½ to 3 cu. ft. of exhaust gases were produced per minute when it was run at the minimal speed of 400 r.p.m.

(5) Coal Gas

This consists of a mixture of approximately 47 per cent hydrogen, 36 per cent methane, 8 per cent carbon monoxide, with a small proportion of carbon dioxide, nitrogen, and hydrocarbons other than methane. The composition varies widely with the nature of the coal used and method of manufacture. Its lethal action is due to the production of anoxia by asphyxiation produced by the oxygen-free gases present, together with anoxæmia produced by the carbon monoxide present. Saturated hydrocarbons of the methane series are not distinguished by having marked anæsthetic and narcotic properties as are the unsatured olefinic series. It is likely, however, that the methane content of coal gas does contribute some degree of narcosis to the lethal action of the gas.

Tests were made in Kilner jars which were filled with various concentrations of the gas.

The symptoms produced by coal gas appeared similar to those of nitrogen, the convulsions in the unconscious stage, however, were not quite as violent. The muscle tissues of the dead chicks were invariably deep red, indicating the production of carboxyhæmoglobin. The carbon dioxide present was insufficient to produce dyspnœa. Low concentrations, although prolonging the time before unconsciousness occurs, result in death being produced within ten minutes. This is probably due to the cumulative effect of the carbon monoxide present.

(6) Butane (Calor Gas)

The lethal action of this gas is due to anoxia produced by asphyxiation coupled with a certain degree of narcosis. Like methane, butane is not characterised by marked anæsthetic and narcotic properties, but data which has been published shows that when rats were exposed to 63,000 p.p.m. of butane with no oxygen deficiency, stupor was produced, which indicates that butane does possess some degree of anæsthetic activity.

Table 6. The lethal action of butane.

Gas concentration %	Preanaesthetic stage		Post anaesthetic stage	
	Duration seconds	Symptoms.	Duration seconds	Symptoms.
100	20-45	No awareness. Stupor produced followed by collapse.	110 - 160	Slow shallow respirations for 45 seconds followed by weak convulsions for 30 seconds. This was followed by infrequent respiratory movements for another 30-90 seconds.
50	360 - 400	No awareness. Stupor produced followed by collapse.		Deep irregular breathing. Still moving after 14 minutes. Showed no reflexes when removed. Recovered within 5 minutes.

Tests were made in Kilner jars using varying concentrations of butane.

The symptoms produced by butane appeared similar to those of coal gas but the convulsions were weaker and in some cases were absent. Death within ten minutes was found to be dependent on the maintenance of a high concentration of gas. The anoxia produced was found to be reversed when unconscious chicks were given access to air.

(7) Carbon Tetrachloride

At temperatures below 78° C. this is a liquid which rapidly evaporates at normal room temperature. The maximum vapour concentration in air is related to the air temperature. A higher concentration and consequently a quicker lethal action is obtained at high temperatures and vice versa.

The lethal action is a narcotic one. Carbon tetrachloride is absorbed by the blood in the respiratory organs from which it penetrates the nervous system, causing respiratory paralysis.

Tests were made in the special chamber, and in the R.S.P.C.A. box at room

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temperature, and in Kilner jars at higher and lower temperatures. Air saturated with the vapour was used for each test. In the case of tests made in the special chamber, this was produced by spreading a cloth saturated with 10 ml. of carbon tetrachloride on the base of the chamber. In a container such as the R.S.P.C.A. box, which was deep enough to take three layers of chick boxes, it was found necessary, for the even distribution of the vapour, to vaporise the carbon tetrachloride at the upper part of the box so that the heavy vapour sank to the bottom. If the liquid is placed at the bottom of the box it becomes covered with a layer of vapour which checks further evaporation. Used in this way, chicks in the top layer of boxes would not be exposed to a lethal dose of vapour. The method adopted for killing chicks in the R.S.P.C.A. box at room temperature, therefore, consisted of pouring carbon tetrachloride over a piece of hessian spread over the top of the chick boxes. The R.S.P.C.A. box was then sealed by lowering the lid. Although 60 ml. was sufficient to saturate the air in the box, 120 ml., by having a greater surface area for evaporation, produced saturation more quickly. If the chamber was to be used for destroying a number of batches of chicks in quick succession, 120 ml. was used initially, and 60 ml. for subsequent use, as a

Table 7. The lethal action of carbon tetrachloride.

Container	Temp.	Preanaesthetic stage		Postanaesthetic stage	
		Duration seconds.	Symptoms.	Duration Seconds.	Symptoms
Special chamber	20°C.	120	Some degree of awareness. Movements suggest mild irritation of eyes. Some muscular inco-ordination followed by collapse.	120	Slow shallow respiratory movements. Convulsive movements slight or absent.
Kilner jar	28°C.	80-90	As above.	130-140	As above.
Kilner jar	20°C.	70-120	As above.	90 - 120	As above.
Kilner jar	4 - 6°C.	140-160	As above.	240 - 300	As above.

proportion of the carbon tetrachloride used earlier was left unevaporated in the hessian. As the boxes were covered with hessian it was not possible to observe symptoms; the sounds of movements in the box were noted, however, and all movements ceased within five minutes of the chicks being sealed in the box. All the chicks were dead when removed five minutes later. Eighty to ninety chicks were used in the tests with the R.S.P.C.A. box; these were distributed evenly among the nine chick boxes. In the tests made with Kilner jars the glass lids were replaced by filter papers to which carbon tetrachloride was applied at intervals so as to maintain a saturated atmosphere in the jars. The jars containing the chicks were adjusted to the test temperatures before saturating with carbon tetrachloride vapour.

The narcotic action of carbon tetrachloride was obvious from the symptoms of the exposed chicks. Convulsive movements were slight or absent, as opposed to the violent convulsions which were obtained when nitrogen was used. The lethal action of carbon tetrachloride at low temperatures was slower, due to a

lower air saturation concentration. This suggests that when it is used in an R.S.P.C.A. box under cold conditions, the period of exposure should be extended to at least 15 minutes.

(8) Chloroform

This is a liquid at temperatures below 61° C. with physical and lethal characteristics similar to that of carbon tetrachloride, from which it differs chemically by having three atoms of chlorine linked to its carbon atom instead of four.

Tests were made in the same manner as described for carbon tetrachloride, from which no difference was observed in the symptoms which occurred either before or after loss of consciousness. Chloroform, however, produced unconsciousness quicker than carbon tetrachloride in a vapour-saturated atmosphere. At room temperature (20° C.) unconsciousness was produced twice as quickly and at low temperatures (4° to 6° C.) three times as quickly. The duration of the post-anæsthetic period with chloroform, however, was longer, being twice that of carbon tetrachloride at normal room temperature.

The duration of the period of exposure to chloroform necessary to obtain 100 per cent mortality was 50 per cent greater at a temperature as low as 4° C. When used in an R.S.P.C.A. box in the manner described for carbon tetrachloride an exposure period of ten minutes was required at 20° C. and at least 15 minutes would be required at 4° C. The amount of chloroform found necessary was 60 ml. for initial and repeated use.

Discussion

The principal difficulty in interpreting the results of the tests described is in deciding (1) whether the chicks were in pain or distress before collapse, and (2) whether they were completely unconscious during the period when convulsions occurred.

Chicks are incapable of registering distress other than by chirping vigorously and making efforts to escape. These symptoms were seen only when asphyxiation was produced in a lethal chamber using a high flow rate of nitrogen. Chicks were aware of a change in their environment when exhaust gases and carbon dioxide were used, but struggling was absent in each case, presumably because some degree of anæsthesia was being produced. With carbon dioxide the chicks became comatose rapidly. It appears, therefore, that none of the agents tested can be considered to cause undue distress to chicks before they collapse, with the exception of nitrogen when this is used at high flow rates in a lethal chamber. This, and other methods such as drowning and smothering, which involve rapid asphyxiation without anæsthetisation, are therefore unsuitable for chick destruction.

According to investigations made with human subjects, the convulsive movements produced by nitrogen asphyxiation are considered to occur after loss of consciousness. In the tests, convulsions usually occurred some time after

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collapse so that it is likely that consciousness was at low level or completely absent at that time. In the case of asphyxiation with carbon monoxide, however, convulsions occurred before collapse and apparently before loss of consciousness. With the other agents tested, narcosis was produced to a varying degree as the convulsions were less frequent and violent, and in the case of carbon dioxide convulsions were rare. If convulsions are regarded as undesirable symptoms in chick destruction, nitrogen and carbon monoxide would not be suitable agents, but carbon dioxide, chloroform, carbon tetrachloride, butane, coal gas and exhaust gas would be suitable in this order.

It is essential with lethal agents in which the anoxia or narcosis can be reversed by removing chicks, exposed to sublethal doses, to the air outside the chamber, e.g., nitrogen, carbon dioxide and butane in particular, that the lethal agent is maintained at a high concentration in the chamber for a sufficient length of time. With carbon dioxide and butane, chicks can recover completely from a state of deep narcosis which would be difficult with superficial examination to distinguish from death. In the case of mixtures of gases which include carbon monoxide, such as coal gas and exhaust gas, this factor is not quite so important owing to the difficulty with which carbon monoxide poisoning can be reversed.

With regard to the relative merits of carbon tetrachloride and chloroform as lethal agents, chloroform, by virtue of its speedier action especially at low temperatures, appears the more suitable for use.

From the practical viewpoint all the agents used in the tests with the exception of carbon dioxide and nitrogen suffer from the drawback that they must be used in outside chambers or in specially ventilated rooms. Butane and coal gas produce explosive mixtures with air when they are liberated from the chambers and this introduces an additional drawback to their use.

Carbon monoxide is of experimental interest only, as its toxicity in low concentrations would make it too dangerous to hatchery personnel for it to have any practical application.

Nitrogen would be an impractical agent for use owing to the bulky nature of its cylinders. Carbon dioxide is more compressible than nitrogen so that similar volumes of gas can be stored in smaller cylinders, but even so, the capacity of cylinders of manœuvreable size would be insufficient to meet the needs of the larger hatcheries. Furthermore, its mode of lethal action coupled with the necessity for special equipment for its use does not give it any particular advantage over the use of carbon tetrachloride or chloroform for use on a small scale.

Conclusions

From these considerations it appears that petrol engine exhaust gas is the most efficient agent for destroying chicks on a large scale, using a specially-designed chamber in the manner already detailed. The essential features of this method of chick destruction are, that the engine is run at minimal speed,

using as much choke as possible without the production of soot, and that the chamber is left sealed for a minimum time of three minutes after it has been filled with gas. Due care should be taken that undesirable temperatures are not reached in the lethal chamber and that where necessary the exhaust gas be cooled in a water jacketed pipe.

For use on a small scale, chloroform appears to be the most efficient, and is best used in conjunction with an R.S.P.C.A. container. Using the large container, which measures 17 in. x 17 in. x 30 in., 60 ml. (2 fl. oz.) of chloroform is required. This should be vaporised from the upper part of the container in the manner previously described, and the container left sealed for a minimum time of ten minutes. At low temperatures the exposure time should be extended to 15 minutes.

It is considered advisable, in order that uniform results are obtained with the method selected, that when the chambers are not filled to capacity with chicks, the empty space should be filled up with other material. A standard procedure for the destruction of chicks with the lethal chamber can then be evolved which should be strictly adhered to.

Whatever method of destruction is chosen it is important that the chicks be kept during the period between sexing and destruction in as comfortable an environment as if they were intended for sale. The best type of containers for holding the chicks before and during destruction are chick boxes. These can be used without internal fittings if the chicks are kept for a short time in a warm atmosphere until they are transferred to the lethal chamber. Alternatively, the chicks may be kept in trays on a racked trolley which can be wheeled into the chamber.

Summary

(1) The mode of action on chicks of a number of lethal agents has been investigated.

(2) Recommendations have been made on their degree of suitability for destroying surplus chicks from both a practical and a humane aspect.

(3) Petrol engine exhaust gases and chloroform are considered to be the most suitable agents for the use of the large and small operators respectively. Practical details have been given of the manner in which these are best used.

(4) Methods of destruction which involve abrupt asphyxiation with no narcotic depression were found to induce apprehension and struggling before loss of consciousness and are therefore undesirable. This includes methods such as drowning or smothering.

(5) Attention has been drawn to the necessity for the chicks to be under comfortable conditions before they are destroyed.

Acknowledgments

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gift of two lethal chambers; to Shell-Mex and B.P. Ltd. and the Ford Motor Company for technical data on exhaust gases, and to the Calor Gas Company and the Carbon Dioxide Company for information on their products. We also acknowledge with thanks the co-operation given by the Technical Developments Committee of the Chick Producers' Association.

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EFFECTS OF THE THYROID GLAND ON FLEECE GROWTH IN SHEEP

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MARSTON (1946) states that there is little exact knowledge of the different physiological processes involved in the production of wool. During the past few years some useful work has been done on Merino sheep to study the influence of nutrition, but very little has been done to elucidate the role of various hormones in the regulation of wool growth. According to Marston (1948) the rate of wool production depends primarily on the amount of protein ingested by the sheep and the efficiency with which the animal converts its fodder protein to wool fleece is influenced by a number of physiological factors. There can be no doubt that the initial nutritional limitation is imposed by the potential capacity of the fodder to provide cystine, and the ultimate supply of essential amino-acids that become available to the follicles is subject to competitive reactions which change both in nature and extent with the over-all nutritional status of the animal. Ferguson, *et al.* (1948) stated that on general considerations it seemed likely that the relation of wool-growth rate to the nutrient intake would follow the familiar law of diminishing returns.

Marston and Peirce (1932) reported that thyroidectomy arrested the rate of wool growth in the sheep. According to Emmens (1942) the literature dealing with the influence of endocrine organs on hair growth in the rat is not extensive and the results reported are by no means concordant. Emmens (1942) observed that thyroidectomised female rats exhibited less rapid and less complete hair growth than normal. The author further reported that female rats exhibited increased hair growth when treated with a crude saline extract of the pituitary

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gland of female rats but were insensitive to acetone-dried material from the same source. Male rats were unaffected by a crude saline extract of mixed rat pituitaries. Ferguson (1951) reported that in five weeks complete hypophysectomy in the sheep reduced the rate of wool growth to about one tenth of the pre-operation rate. In sheep incompletely hypophysectomised, wool growth rate returned to the control level after a transient depression.

Since thyroid hormone regulates about 40 per cent of the body metabolism in sheep and as stated by Marston (1948) the growth of wool is influenced by the plane of nutrition, a preliminary investigation was undertaken to study the effect of continued administration of thyroidal material and goitrogens on the rate of wool growth in the growing sheep. The results of these experiments, briefly reported by Maqsood (1950*a*), are described in this paper. The work under report was carried out at the Animal Research Station, University of Cambridge, England, during the years 1949-50. Further work on this problem is still being continued at the Punjab College of Animal Husbandry, Lahore.

Materials and Methods

(1) Animals.

Suffolk rams used in this experiment were closely inbred at the Animal Research Station, University of Cambridge, England, during the year 1949-50. Each ram was numbered individually and they were divided into three groups so that the average group body-weight was about 82.5 lb. At the start of the experiment the average age of the rams in each group varied from 16 to 18 weeks. Throughout the experimental period of 11 months each ram was fed from 1½ to 2 lb. of concentrates daily and during the winter months they were fed also on mangold and hay. Water was available *ad libitum* and mineral salt tablets were provided for licking. During summer, 1949, the rams were kept in grass paddocks and from mid-September, 1949, to August, 1950, they were kept individually under a shed which was subdivided into eight small pens. The rams were turned out in a grass paddock for exercise on every third day. Phenothiazine was administered periodically to all the rams as a precautionary measure against internal parasites.

(2) Experimental Drugs.

(*a*) Iodinated casein under the trade name of *Protamone* (containing 0.72 per cent 1-thyroxine on bioassay) was kindly supplied by the Cerophyl Laboratories, Kansas City, U.S.A. Keeping in view the possibilities of the practical application of thyroid therapy in the field of Animal Production, it was decided to feed iodinated casein mixed in the ration as it can be fed easily by the farmers under field conditions. (*b*) Thiouracil (*2-thio-6 oxypyrimidine*) was supplied by Lederal Laboratories, Pearl River, New York. Thiouracil is a goitrogen which has practically no toxic effects when administered to ruminants.

(3) Procedure.

(*a*) *General.* Each ram in Group No. 1 was fed daily with 1 gm. of Protamone during August-September, 1949, 1.5 gm. from October, 1949, to

PLATE I

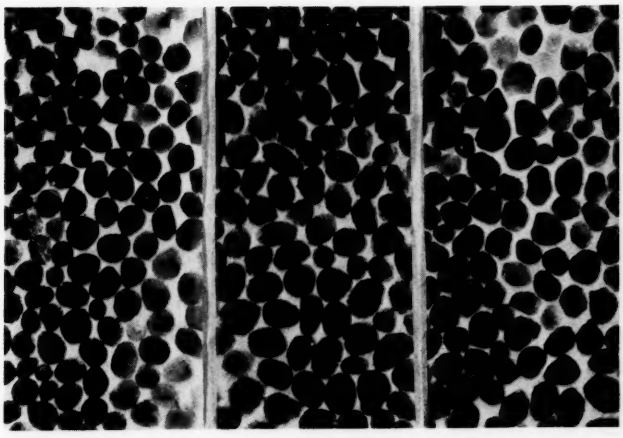

Fig 1

Micro-projections of the cross sections of wool fibres showing the effect of the administration of thyroid hormone and thiouracil on the fibre diameter of the treated sheep. (Left : hyperthyroid ; middle, control and right : hypothyroid.)

Fig 2

Photograph of wool samples showing the effects of the administration of thyroid hormone and thiouracil on the fibre length of the treated sheep. (Left : control ; middle, hypothyroid and right : hyperthyroid.)

(*Article by Maqsood, page* 163)

PLATE II

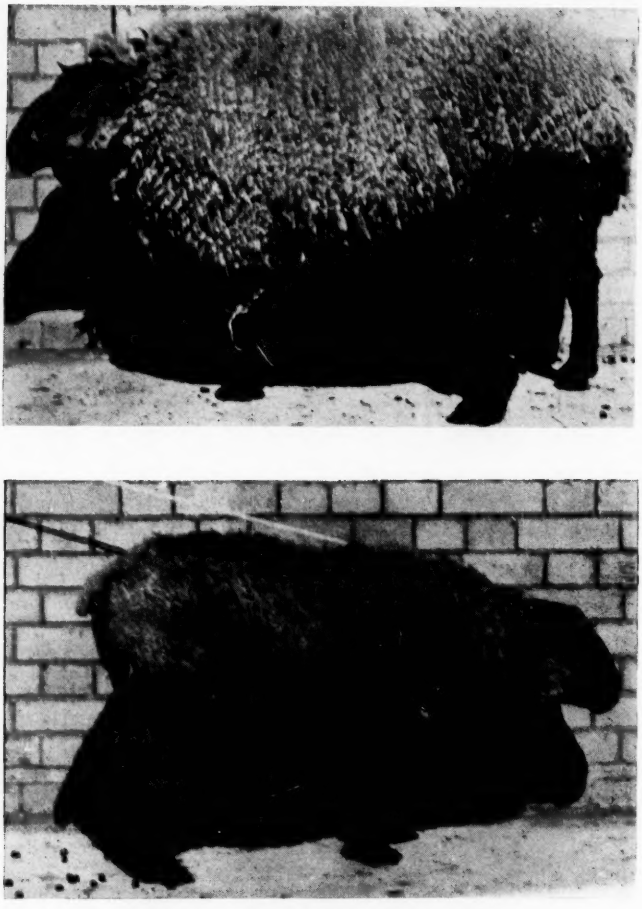

Fig 3

Showing the effect of the administration of thyroid hormone and thiouracil on wool growth and body weight of the treated sheep. (Upper: hyperthyroid ram; and lower: hypothyroid ram.)

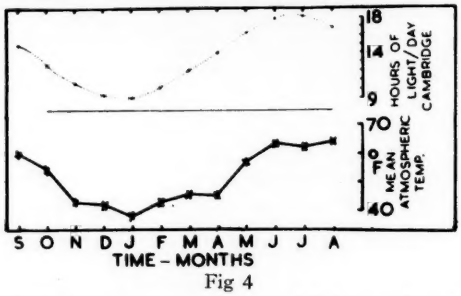

Fig 4

Mean atmospheric temperature and hours of light per day of Cambridge (approximate latitude 52° N.) during the years 1949-50.

(*Article by Maqsood, page* 163)

March, 1950, and 1.25 gm. during the rest of the experimental period. Each ram in Group No. 2 was given 10 gm. of thiouracil daily from August to November, 1949, 12 gm. from December, 1949, to March, 1950, and 10 gm. for the rest of the experimental period. The rams of Group No. 3 were kept as controls. All the animals were weighed weekly during the first half and fortnightly during the second half of the experimental period. The rectal temperatures of all the rams were recorded weekly during the first half and fortnightly during the second half of the experimental period. The effects of thyroid therapy on the body-weight and temperature of the treated animals have already been reported (Mapsood, 1951*b*. 1953). The wool samples from all the animals were collected in the region of the proximal 1/6 of the 8th intercostal space at the end of eleven months' treatment period. The rams were then sheared and the weight of wool-yield of each animal was recorded separately.

(*b*) *Measurement of fibre length.* The clean samples of wool from each ram were placed on a board covered with black velvet. Twenty fibres were then drawn one by one and their lengths determined by gently stretching until the kinks disappeared and they became straight. The length of each fibre was recorded to the nearest millimetre on a scale which was placed by the side of the board.

(*c*) *Measurement of fibre diameter.* Micro-projections of the cross sections of wool fibres of each sample were photographed at a magnification of 500 times. From these photographs the diameters of 20 fibres were calculated.

(*d*) *Statistical analysis.* Statistical analysis of the data was carried out after Fisher (1946). The level of significance was determined by comparing the values of the experimental groups with those of the control group, No. 3.

(*e*) *Atmospheric temperature and light hours.* As the atmospheric temperature and light hours appear to affect the rate of secretion of the thyroid hormone in some species of animals (Maqsood, 1950*b*, and Puntriano and Meites, 1951), the mean atmospheric temperature calculated from the daily maximum and minimum temperature for the year 1949-50 is plotted in Fig. 4. From the *Nautical Almanac* (1949) the hours of light per day from September to August were calculated for latitude 52° N. (the approximate latitude for Cambridge) and plotted in Fig. 4.

Results

(*1*) *Fibre Diameter.*

The mean fibre diameters of the thyroid hormone treated, thiouracil-treated and controls rams were 28.4, 27.3 and 28.1 μ respectively (Table I). Fig. 1 shows the difference in the cross sections of wool fibres of the animals in the three experimental groups. Statistically the differences in fibre diameters in all these groups were not significant.

(2) Fibre Length.

The mean fibre lengths of the thyroid hormone treated, thiouracil-treated and control rams at the age of about 15 months were 24.3 ± 0.045, 10.4 ± 0.022 and 18.6 ± 0.035 c.m. respectively (Table I). The increase in the fibre length of the thyroid hormone treated rams were statistically significant at 0.1 per per cent level of *P*, when compared with that of the control group No. 3 (t = 23.85 ***). On the other hand prolonged thiouracil-treatment for a period of 11 months resulted in a significant decrease in the fibre length of the treated animals. The general characteristics of the wool fibres are shown in Fig. 2.

GROUP No.	No. of Animals	TREATMENT	FIBRE DIAMETER (1) ± S.E. (M)	t	FIBRE LENGTH (1) ± S.E. (C.M.)	t	WOOL WEIGHT (1) ± S.E. (lbs)	t
1	3	Protamone	28.4 ± 0.025	0.349 (N.S)	24.3 ± 0.045	** 11.725	12.83 ± 0.259	** 6.517
2	2	Thiouracil	27.3 ± 0.062	1.759 (N.S.)	10.4 ± 0.022	*** 23.85	3.95 ± 0.530	*** 15.335
3	2	Control	28.1. ± 0.122		18.6 ± 0.035		9.8 ± 0.212	

Level of significance: ** = 1% *** = 0.1% N.S. = Non-significant S.E. = Standard error
(1) t = Values obtained by comparing group 3 with 1 & 2.

TABLE 1.
Showing the effects of continued administration of Protamone(containining 0.72% l-thyroxine on bioassay) and thiouracil, on the fibre-diameter, fibre-length and wool weight of the treated Suffolk ram kept at Cambridge, England. The various treatments were started at the age of about 4½ months and continued for a period of 11 months.

(3) Wool Yield.

Fig. 3 shows the general effects of the administration of thyroid hormone and thiouracil on wool growth in the sheep. The mean wool weights of the thyroid hormone treated, thiouracil treated and control animals at the age of about 15 months were 12.83 ± 0.259, 3.95 ± 0.530 and 9.8 ± 0.212 lb. respectively (Table I). Thyroid therapy resulted in a significant increase in the wool weight of the treated animals when compared with that of the control group (t = 6.517 **). Chemical thyroidectomy produced by the continued administration of thiouracil, resulted in a significant decrease in the wool weight of the rams when compared with that of the control group (t = 15.335 ***).

Discussion

Marston's work (1948) on Merino sheep in Australia indicates that the rate of wool growth is practically always limited by nutritional factors. The quality and quantity of the fodder consumed by the grazing sheep in Australia vary over a wide range according to the season and all these variations are reflected in the fleece by alterations both in length and in the mean diameter of the wool fibres. The rate of wool production depends primarily on the amount of protein ingested by the sheep and this relationship may be complicated by the state of the energy balance. In the region of energy equilibrium, when the intake of other nutrients is insufficient to provide for the total energy require-

ments of the animal, some of the proteins of the diet which otherwise would be available for wool growth is drawn on to provide energy for other metabolic processes. When a sheep is in a positive energy balance the rate of its wool production is proportional, over a wide range, to the protein intake.

Marston (1948) further states that the response of individual follicles is by no means constant and no alteration of the nutritional level of the sheep leads to a marked change in the nature of the fibre diameter distribution curve. As the follicles have little or no capacity to store their requirements of amino-acids, wool growth is essentially dependent on the concentration of amino-acids in the tissue fluids. The continued high concentration of amino-acids in the systematic blood stream which apparently is necessary to sustain maximum wool growth tends to favour wastage of the substrate by oxidative deamination, even at food intake which ensure a strong positive energy balance. The ultimate nutritional status that determines the rate of wool growth is the concentration and composition of the assemblage of amido-acids in the tissue-fluid which surround wool follicles. The amount of the absorbed amino-acids which eventually become available to serve as a substrate for wool production, is influenced by physiological interactions that might be expected, *a priori,* to alter with the nutritional state of the sheep. It is true that the role of nutrition in the study of wool growth cannot be overlooked but the effects of the thyroid hormone—the so-called regulator of body metabolism—may also be taken into consideration while investigating the problem of wool growth as such a study is likely to contribute towards the understanding of the mechanism of the regulation of wool growth in the sheep.

The present data indicated that the continued administration of thyroidal material in suitable doses to Suffolk sheep kept in England resulted in a significant increase in fibre length and wool yield while on the other hand continued administration of various goitrogens resulted in a significant decrease in fibre length and wool yield. Ferguson (1951) reported that complete hypophysectomy in the sheep reduced the rate of wool growth to about 1/10th of the pre-operation rate in 5 weeks time. The preliminary results of replacement therapy suggested the effects of hypophysectomy were not due to a simple growth hormone deficiency. Moreover, Evans, *et al.* (1939), and Scow and Marx (1945) state that there are some indications that the thyroid hormone is necessary for the normal elaboration of hypophyseal growth hormone.

How the thyroid hormone influences the rate of wool growth in the sheep needs further investigation. There are indications that the thyroid hormone by increasing the body metabolism with anabolic effects, in part, stimulate wool growth while in the hypothyroid sheep, the resulting decrease in the metabolic rate interferes with the normal fleece growth. It may be of some interest to mention here that the mechanism of regulation of the secretion of the thyroid hormone is directly or indirectly linked up with some other endocrines and the rate of its secretion is further influenced by a number of factors. In view of the work done in the field of hormones and wool growth, it may be suggested

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that the thyroid hormone in combination with the growth hormone plays an important role in the regulation of wool growth. Further work in this field will greatly help in elucidating the mechanism of the hormonal control of wool growth in the sheep.

It may be stated that thyroid therapy throughout the experimental period of 11 months did not result in a significant increase in the body temperature of the treated rams. On the other hand, such a treatment resulted in a significant increase in the body weight gains and considerably improved the various male reproductive processes and prevented the seasonal decline in the fertility rate in the sheep (Maqsood, 1951b, 1953). These findings indicated that the administration of thyroidal materials in physiological doses did not affect the animal body adversely. However, the effects of prolonged administration of thyroidal materials on various other physiological processes and on the life span of different species of animals needs investigation.

Summary

The continued oral administration of thyroidal material in suitable doses resulted in a significant increase in the fibre length and wool yield of the treated Suffolk sheep, kept in England. Chemical thyroidectomy produced by the continued administration of thiouracil resulted in a significant decrease in fibre length and wool yield of Suffolk sheep. In both these lines of treatment the difference in the fibre diameters was not significant when compared with the control sheep. How the thyroid gland appears to influence the rate of wool growth in the sheep is discussed in the light of the previous work.

Acknowledgments

The author is grateful to Dr. J. Hammond, C.B.E., D.Sc., F.R.S., and Dr. A. Walton of the University of Cambridge, England, for providing facilities to work in their laboratories; to Dr. Sven Skarman, Wool Laboratories, Waid, Sweden, for sectioning the wool samples; and to Dr. A. B. Wildman, Chief Biologist, Wool Industries Research Association, Leeds; Mr. S. M. A. Shah, B.Sc., M.R.C.V.S., Director, Animal Husbandry, Punjab, and Mr. S. M. Sarwar, M.B.E., M.R.C.V.S., Principal, Punjab College of Animal Husbandry, Lahore, for their valuable suggestions. Thanks are also due to Mr. Mumtaz Ali, M.A., for the statistical analysis of the data and to the staff of the Animal Research Station, Cambridge, for the care and feeding of the experimental animals.

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VAGINAL AND UTERINE ANTIBODIES IN CATTLE WITH PARTICULAR REFERENCE TO *Br. Abortus**

By W. R. KERR

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One of the complexities in the control of venereal disease in cattle is the difficulty of finding satisfactory serological tests. In vibriosis the serum agglutination is unreliable in that so many affected animals give a negative test and others may show a transitory agglutination only. To some extent the same difficulty exists in trichomoniasis for when the protozoan is present in large numbers the serum agglutination gives good results but in the less acute and milder forms of the disease the test of the individual is less satisfactory and more reliance must be placed on the test as a herd test. In both cases the use of the vaginal mucin test is more accurate. Brucellosis does not present quite the same problem as vibriosis and trichomoniasis but it has to be considered in diagnostic tests of infertility. In particular, because of the more or less universal use of S.19 vaccination in cattle the difficulty exists in determining whether serum titres are vaccinal in origin or in fact due to a suppressed virulent infection following sporadic vaccination.

The purpose of this paper is to present some evidence of the local production of antibodies in the uterus and vagina and their relation to the diagnosis of the bacterial and protozoal antigens concerned. The author, in collaboration with M. Robertson, has published a number of papers on the antibody response of cattle to *T. fœtus,* and two in particular are directly concerned with the production of antibodies by the uterus (1943, 1953). From these, two conclusions were reached which are concerned with the present paper and, indeed, the present work is a further exploration of these conclusions using *Br. abortus* as the antigen and examining the findings in the light of the problems of diagnosis and immunity. The two conclusions were:—

(1) That antibodies occur in the uterus and can be withdrawn by irrigation; moreover, these antibodies result from the introduction of antigen into the lumen of the uterus and are produced locally by the uterine cells.

(2) That free antibody to *T. fœtus* in the uterus is not produced by intramuscular injection even when antibody has circulated in the blood stream for long periods.

* Presented to a meeting of F.A.O. at Copenhagen, December, 1954.

Further reference may be made on this subject to an interesting paper by Pierce (1953) on Specific Antibodies at Mucous Surfaces in which he discusses the presence of antibodies produced on the mucous surfaces of bowel, lung and vagina. It is an interesting fact that antibodies detected in the mucin from the uterus and vagina have been studied exclusively in cattle and are of considerable veterinary interest.

Materials and Methods

Antigens.

(1) Live *Br. abortus* S.19 vaccine. (Unit dose 5 ml.)

(2) An alcohol precipitate of S.19 vaccine prepared as follows: The concentrated live S.19 suspension was precipitated by 95 per cent alcohol, centrifuged, the precipitate then washed in acetone, recentrifuged and again washed in acetone and centrifuged. Finally the precipitate was washed in ether and dried in the incubator at 37° C. and 0.1 gm. of this antigen was injected intramuscular into a normal ox to test its antigenicity. It produced a titre of 1/1280.

Uterine Wash Samples.

A sterile catheter was passed into the uterus and approximately 60 ml. of sterile physiological saline injected. The uterus was then massaged and the fluid aspirated by means of a syringe into a sample bottle. If the uterus is not too large this is comparatively easy but a large and flacid uterus presents some difficulty. The amount of mucin in a normal uterus is probably small and the 60 ml. of saline solution used would indicate a great dilution of antibodies, therefore their presence in the wash is regarded as more qualitative than quantitative.

Vaginal Mucin.

These samples were taken by means of glass tubes in the orthodox manner described by Pierce (1946).

Serological Tests.

The serum tests were set up in the usual manner, using the carbolised standard *Br. abortus* antigen prepared by the Ministry of Agriculture Laboratories, Weybridge.

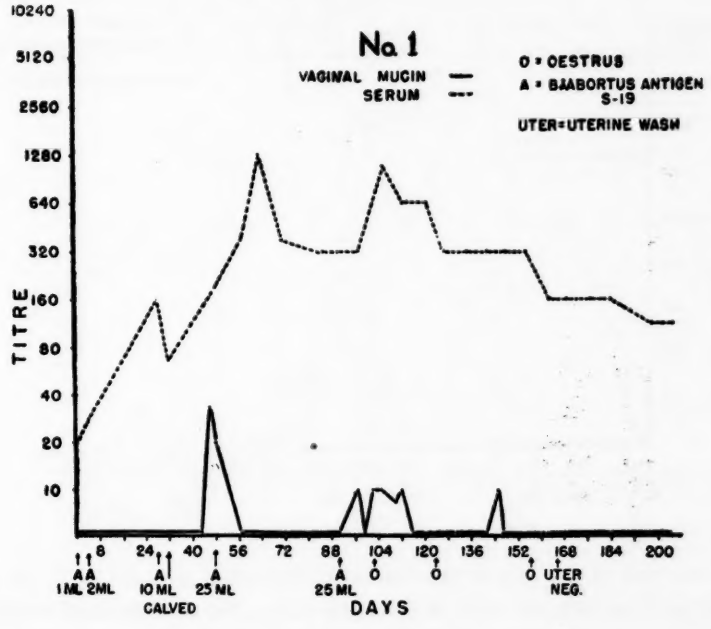
The uterine wash samples were tested as in the serum tests replacing the serum with uterine wash.

Vaginal mucin agglutination test: In the early stages of these tests the agar plate method described by Pierce (1946) was used with excellent results but experimentation showed that equally good results could be achieved with a direct test and this for our purpose was preferable in that we could get a better and more constant titration. The mucin sample and saline solution are added together to make a dilution of 1-5, then placed in a Griffith tube and broken down. The first tube dilution is 1-10 and thereafter dilutions are doubled as

in the serum test. The antigen is again the same as in the serum tests. The tubes of vaginal and uterine dilutions are inactivated in the water bath at 56° C. for one hour, then incubated overnight at 37° C. One advantage of the heating to 56° in the water bath is that in conjunction with the carbolised antigen it controls contamination. The tests have always been found to be water clear and easy to read. An interesting feature of these tests was that we found "prozoning" to be well marked and it was not uncommon to find this appearing in the first three dilutions while the remainder showed complete agglutination. One high titre mucin was "prozoned" to 1/160.

Group I (Cows Nos. 1 and 2)

Massive doses of live S.19 vaccine were injected by the subcutaneous route in order to observe the passage of antibodies to the uterus.



Pierce (1953) failed to detect antibody to *Br. abortus* in vaginal mucin except where the titre reached 1/1280. Our own experience of large numbers of vaginal samples taken from herds known to be vaccinated with S.19 and free from a virulent strain of abortus was one of complete negatives. The serum titre arising in a normal bovine animal vaccinated with 5 ml. of S.19 vaccine is, however, not great and certainly would not reach a titre of 1/1280. These observations are not satisfactory evidence and lack the essential detail to give a positive finding. Live organisms when used may appear in any tissue and therefore the presence of antibodies would not be evidence of the passage of

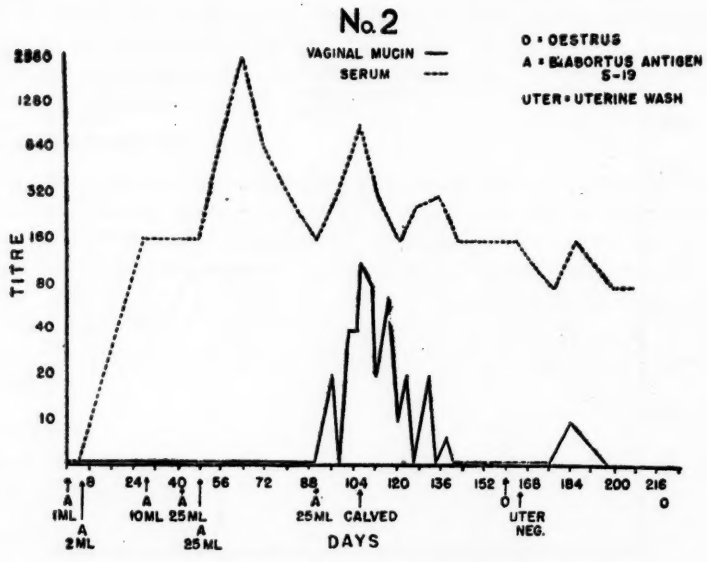
preformed antibodies into the uterus. Again no account is given of transitional positive titres that may take place as found in experimental animals. Moreover, without a long and continued sampling a definite finding could not be obtained.

The two cows in this group were injected intramuscularly with a total of 63 ml. of live S.19 vaccine in 5 injections over a period of 90 days.

No. 1 (Graph 1)

The highest serum titre reached was 1/1280 and at the end of the experiment of 208 days was still 1/160. This cow calved at the 32nd day following the initial injection of vaccine.

The vaginal mucin titre remained negative until the 43rd day when a positive titre of 1/20 was found and persisted for two days. The appearance



of the low titre in this case at the time of parturition occurred also in the other animal of this group and will be discussed later. Small amount of antibodies (partial in 1/10) also appeared at the 100th and 144th day.

The antibodies in these transitory appearances did not persist for more than two days.

No. 2 (Graph 2)

This cow calved at the 104th day following the first injection of vaccine. The highest point of the serum titre 1/2560 was reached at the 56th day after the first injection and at the 208th day was still 1/80.

The vaginal mucin, despite the high serum titre of 1/2560 at the 56th day, remained negative until the 90th day when the first evidence of antibodies

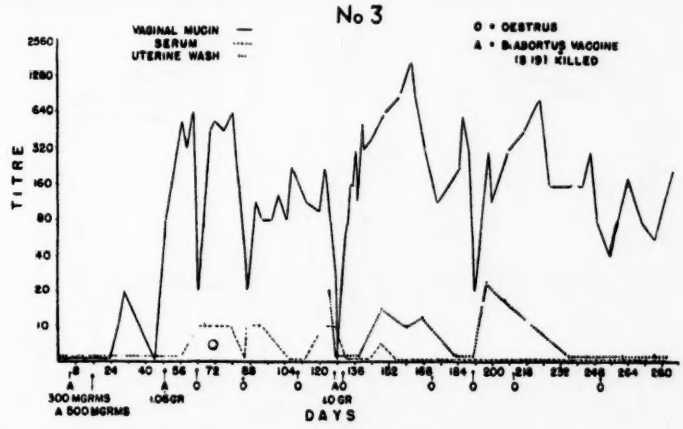
appeared; these persisted until the 140th day and at its highest point was 1/80.

A low titre (1/10) also appeared at the 180th day, thereafter until the end of the experiment the vaginal mucin remained negative.

The passage of antibodies associated with parturition is possibly one of permeability of the uterine wall following the changes of the mucosa at parturition. This is a major event and must involve great physiological changes. The appearance of antibodies in No. 1 cow was at a low titre (1/20). Both calvings were normal. One further point, œstrus was not associated with these "leakages."

The evidence of these two animals is that following massive vaccination of S.19 parenterally little or no passage of antibodies to the uterus takes place except for the phenomenon recorded at the calving period. Also the other point of interest that during the period when the titre was 1/2560 the vaginal mucin was negative.

These results (1) lend support to our contention that "leakages" are unlikely to follow normal vaccination titres; (2) that our field experiences have some significance.



Group II (Cows Nos. 3 and 4)

In these experiments alcohol precipitated S.19 antigen was instilled into the uterus to determine what passage, if any, of antigen or antibodies took place from the uterus to the general system.

Doses of 0.3, 0.5, 1 and 1.0 gm. were instilled into the uterus by means of a catheter and syringe over a period of 40 days. followed by a boosting dose of 1 gm. at the 128th day, making a total of 3.8 gm. The vehicle in each case was 20 ml. of physiological saline.

Vaginal sampling was done twice weekly throughout the experiment of 280 days and at critical periods taken daily. Uterine samples were not taken until the 120th day from the first instillation but thereafter were taken once weekly to the end of the experiment.

Group II (Cow No. 3)

A good vaginal titre of 1/160 was obtained at the 40th day, reaching its highest point 1/1280 at the 160th day and at the end of the experiment of 280 days was still 1/320.

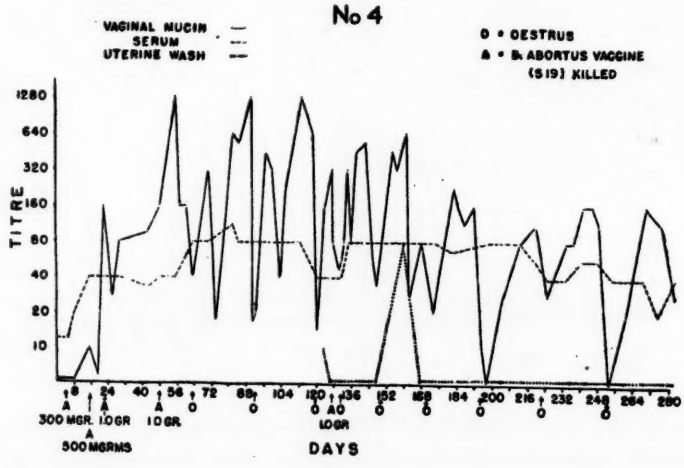
The uterine titre, somewhat transient, made several appearances with a maximum titre of 1/20.

The most notable features of the experiment in this animal are that at no time did the serum titre rise above a dilution of 1/10 and the titre at this level was only transient. Moreover, during the last 150 days of the experiment the serum titre showed no evidence of even partial agglutination in the 1/10 dilutions.

At each œstrus the vaginal titre dropped, making the characteristic dip in the graph, probably due to the dilution factor of the œstral mucin.

Cow No. 4 (Graph 4)

This cow reached a vaginal titre of 1/1280 at the 56th day, reaching that point on three separate occasions, slowly falling to 1/40 at the 280th day.



The uterine titre was evident on two occasions, 1/80 being the highest recorded.

The œstral dips were again marked.

The serum titre rose to 1/80 then levelled out at 1/40. An explanation may be advanced regarding this phenomenon; before the experiment began this animal showed a partial 1/20 titre, which may have indicated an earlier experience to this antigen and would suggest that any slight passage from the instillation could set off the recall mechanism.

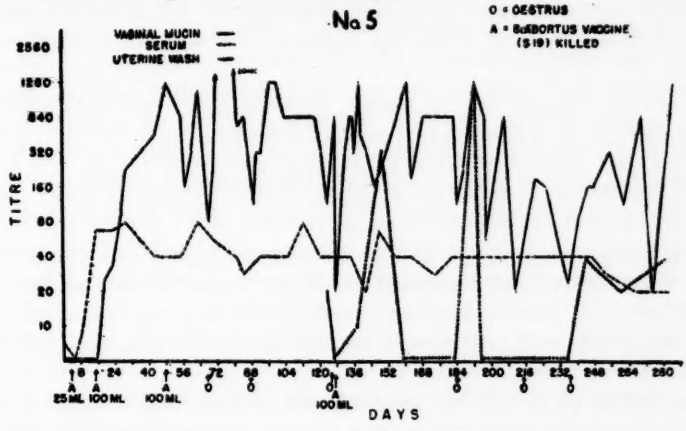
With the exception of the serum titre the history of this animal followed

closely that of No. 3. This group showed that the uterus possessed considerable resistance to the passage of antigen and antibodies into the systematic system. The antigen is an important issue when it is considered that 3.8 gm. were used intra-uterine, yet the same antigen in a dose of 0.1 gm. intramuscularly produced a titre of 1/1280 in a normal animal. In No. 3 there is strong evidence that no passage of antigen took place and there is little evidence that preformed antibodies also passed.

Group III (Cow No. 5)

In this experiment live S.19 was instilled into the uterus. A total of 325 ml. in four instillations were given over 128 days.

Antibodies appeared early in the vaginal mucin reaching a very high titre of 1/20, 480 at the 80th day (this sample was repeated to confirm the high titre). Thereafter a level of 1/1280 with normal fluctuations was maintained until the end of the experiment of 280 days.



The uterine wash taken from the 120th day onwards showed some very high titres, 1/1280 being the highest recorded and at the end of the experiment was still 1/40.

From the 14th day after the last instillation all vaginal and uterine samples were cultured with negative results. It is interesting to observe that the live organism had disappeared from the uterus which showed such a high titre.

The blood agglutinations maintained a level of 1/40 throughout with very little fluctuation. Again, like No. 4, this animal showed a partial titre in this case of 1/10 before instillation. This may be a significant point to avoid in future experiments.

In relation to the high vaginal and uterine titres the serum agglutinations were very low and this would suggest that a passive passage of antibodies does not take place. With regard to the considerable amount of antigen instilled into the uterus, it can be assumed that very little of it had found its way into the systemic system as a good positive titre was never developed.

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Discussion

The production of localised antibodies by the uterus and vagina as determined in the mucin of these organs is of considerable veterinary interest for two reasons, it is concerned with a more realistic approach to diagnosis and to the possible development of a uterine immunity to localised infections.

The first important consideration in discussing this question is that a barrier apparently exists in the non-pregnant uterus (not to be confused with the placental barrier and iso-immune bodies). This barrier has a two-way effect.

(1) The uterus and vagina although richly supplied with blood containing a high degree of circulating antibodies allow little or no passage of antibodies into the lumen of these organs. When using trichomonad antigen Pierce (1953) failed to show passage of antibodies from the circulation into the vaginal mucin. Similarly, Kerr and Robertson (1953) failed to show passage of antibodies from the circulation into the lumen of the uterus. In the present work animals 1 and 2, although possessing high circulating antibodies to *Br. abortus*, resisted the passage of antibodies except during the transient phase associated with the calving period.

(2) On the other side of the barrier, when the uterus and vagina show high titres the passage of antibodies and antigen from the uterus into the circulation does not occur. Particular reference is made to Cow No. 3 in which a high (1/1280) and continued vaginal titre was not reflected in the serum agglutination. That would suggest neither antibodies nor antigen passed through the barrier.

The explanation may be that it is a physical condition associated with molecular size or that the membrane has power to discriminate against antigen and antibody. It is interesting to record that trichomonad antigens do pass through the uterine wall and produce circulating antibodies (Kerr and Robertson, 1943).

The failure of certain naturally-infected trichomonad animals to develop detectable circulating antibodies on that account may be concerned with several explanations, the nature of the antigen and its non-absorption, the quantitative aspect or simply that some animals are poor antibody producers.

With the brucella antigen it is obvious that there is considerable resistance to its absorption from the uterus. It is a well-known experience in the field that the circulating antibodies may not appear to a positive degree until after the act of abortion.

In an early experiment (1938) in brucellosis the author studied the agglutination picture of eleven control cattle infected with *Br. abortus*. Seven out of the eleven animals, although infected, did not show a titre exceeding 1/20 until approaching the act of abortion when the titre rose steeply. In these animals this period of low titre averaged seven months.

Another aspect which is interesting and only speculative is the mechanism whereby the antibodies are produced by the uterus and vagina. The lymphatics are a consideration; these are common to the uterus and vagina and drain into the iliac lymph glands and it would be expected that if they were concerned

that the antibodies would not have a barrier to the general circulation. However, the place where antibodies are found is indeed as yet only speculative and can only be unravelled by detailed experimentation. Pierce (1953) believes that the uterus and vagina are independent of one another and that the vaginal antibodies are produced in the vagina. Kerr and Robertson (1953) believe they are produced locally by the uterine cells. In this connection it is interesting to examine graphs of cows 3 and 4. Here a dead antigen is instilled into a normal uterus followed by a high and persistent titre in the vagina and to some extent in the uterus. It is postulated that primary evidence would suggest the antigen may be absorbed by the surface cells of the lumen of the uterus and therefore the stimulus for the production of vaginal antibodies must also arise from this absorption. An infection by a live organism may give rise to other speculations but here we are dealing with a dead antigen in a relative small volume (20 ml. saline). Three sites are possible relating to the production of antibodies, the uterus, the os and its mucus cells, and the vagina. It is quite possible that the os may be the principal area involved in the production of antibodies. We have not in our recorded experiment excluded leakage of antigen through the os and experiments must be carefully designed to obtain further evidence on this important point. It may be remarked that the epithelium of the uterus is columnar in nature and the vagina squamous. At present the significance that should be attributed to this difference is not apparent.

Whatever the mechanism may be, the ability of these organs to produce locally a high concentration of antibodies is remarkable, particularly in the light of the immunity of these tissues to localised infections. This may readily explain how the uterus clears itself of infection bearing in mind the gross infections that may follow calving and retained after birth. From an academic point of view uterine instillation would seem to be an excellent but perhaps unpractical method of vaccination.

The vaginal mucin test in field work.

The use of this test has a sound practical application in the diagnosis of brucellosis. For reasons advanced earlier in this paper it is considered that the presence of vaginal antibodies in a herd indicate that a virulent strain is present. This is useful information to the clinician. High titres are found in these field samples; 1/1280 is not uncommon and 1/320 is frequently met. They also persist for a long time. 1/320 has been found in a cow which had aborted eight months previously.

A list is added of field tests from two herds showing the relationship of the blood and mucin titres to their abortion times.

" Prozoning " was marked in most of the mucin samples, 1/80 being the highest in this group. At the time of abortion, titres may be low or absent. Dilution of fluids may be one reason. The presence of free antigen and its

absorption may be another. In any case our experience is that the highest titres are to be found from 10 days onwards.

Variations take place both ways in blood and mucin tests but the combined information coupled with the knowledge that a virulent strain is present whether

List of field tests from two herds showing the relationship of the blood and mucin titres to their abortion times.

No.	Blood Titres	Mucin Titres	Aborted
B.3	1/320	1/320	10 days.
B.1	± 1/320	1/320	3 weeks
G.4	—	1/1280	3 "
G.74	1/160	1/1280	3 "
B.2	± 1/320	1/320	4 "
B.4	± 1/320	1/320	4 "
B.6	± 1/320	± 1/320	8 "
G.2	—	± 1/160	8 "
B.5	± 1/320	1/320	12 "
G.3	—	1/160	16 "
G.C.	± 1/320	1/20	16 "
G.B.	1/320	1/40	16 "
G.D.	1/320	1/320	32 "

it be suppressed or not is of material assistance in arriving at an intelligent diagnosis.

Summary

This paper presents some evidence of the local production of antibodies in the uterus and vagina and their relation to infertility diagnosis with particular reference to *Br. abortus*.

It has been shown that a two-way barrier exists in the uterus and vagina.

(1) Circulating antibodies produced by a live injection of *Br. abortus* intramuscularly did not pass into the lumen of the uterus except during the transient phase of the calving period.

(2) High vaginal and uterine antibody titres which followed instillation of a dead abortus antigen did not pass into circulation.

The ability of these organs to produce a high concentration of antibodies locally and its relation to immunity is stressed.

It is considered that vaginal antibodies to *Br. abortus* found in a herd indicate that a virulent strain is present and should be a useful aid to the intelligent diagnosis of this disease.

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REVIEW

DIE BESAMUNG BEIM RIND, by Diedrich Küst and Franz Schaetz. Pp. 149. Stuttgart: Ferdinand Enke, 1954. (Linen bound.) Price DM 19.50.

THIS is a thorough, well-produced treatise dealing with all aspects of the subject of artificial insemination of cattle. The procedures to be used in collecting, examining, storing and inseminating bull semen are covered adequately, and the descriptions are enhanced by the excellent illustrations accompanying the text.

There are chapters dealing with the history and organisation of artificial breeding of cattle, the methods of selecting bulls, and the judgment and evaluation of females used in artificial insemination. These chapters contain much interesting and informative material.

The authors and publishers can be congratulated on producing a practical, lucid, and useful book on an increasingly important topic.

CORRESPONDENCE

To the Editor.

SIR,—I should like to congratulate you on your most excellent Editorial on "The Exodus from the Sudan" appearing in your February number.

You have truly said that many of the officials enter into the spirit of the land which they serve and become "more Indian than the Indians."

It is also only too true that the Exodus from the Sudan is not an isolated incident; it has happened many times before and will probably happen many times again.

Sad as many of us who have had to leave our work in foreign or colonial countries have felt at having to leave our posts, the fact that such countries are considered fit to stand on their own feet and carry on their own government and technical services redounds largely to the credit of those workers who have made this possible and is in reality the greatest reward for their labours.

Yours, etc.,

Fidra,
3 St. Margaret's Road,
Edinburgh, 9.

D. S. RABAGLIATI, B.Sc., F.R.C.V.S., D.V.S.M.

ITEMS OF CURRENT INTEREST

UNDER the presidency of Professor Fluckiger, director of the Federal Veterinary Office, the VIIth International Congress of Comparative Pathology will be held in Lausanne from May 26 to 31, 1955.

According to the programme the opening session will take place on the first day at 4 p.m.; a reception by the president of the Congress will follow. During the scientific meetings reports followed by discussions will be presented on *"Viral diseases transmitted to man by animals"* (ornithosis in pigeon, psittacosis), *"Atmosphere pollution"* (in modern cities; radioactive, cancerogenic, industrial dust; atmosphere and dissemination of phyto-pathogenic germs; toxicity of fog); *"Growth disturbances in comparative pathology"* (vitaminic and alimentary deficiencies, tumoral diseases).

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The General Secretariate in Lausanne, 19 rue César Roux, holds at the disposal of interested persons programmes in French, English, German, Italian. For further information please refer to the General Secretariate.

VERY large doses of vitamin D (30 million units a day) fed to Jersey cows three to eight days before calving in the form of irradiated dried yeast of irradiated ergosterol, succeeded in maintaining calcium and phosphorus levels in the blood and preventing milk fever in cows which habitually suffered from the disease at earlier calvings. These trials are still proceeding at the Ohio Agricultural Experimental Station according to the current number of "Dairy Farmer."

ECHO FROM THE PAST

(*From the* VETERINARY JOURNAL, *April*, 1880.

EDITORIAL.

Glanders in London.

AT the risk of being considered tiresome, we again call attention to the prevalence of Glanders in London, and the absence of efficient inspection to extinguish this dangerous and destructive disease. As will be seen by our Parliamentary report, no few than 116 horses were destroyed in Kensington parish alone in the space of six months, and even that large number my be inferior to the real one. Many veterinary surgeons in London could tell a startling tale as to the extent to which Glanders prevails, and the manner in which its existence is ignored; but as they have no interest in making themselves officious, and as the authorities appear to be quite satisfied with the present methods in regard to its suppression, as well as with the control of knackeries, we suppose the disorder will remain as rampant as heretofore. We certainly cannot discover any greater activity in detecting cases on the part of the local authorities. We trust some active member will take the question up in our new parliament. There is ample material for a good case on behalf of horse-owners and the general public.

NOTICES

MISS F. PEAKE, B.Sc., of Greenford, Middlesex, has been appointed technical assistant in the Veterinary Department of Glaxo Laboratories, Ltd. Miss Peake, who was educated at Wyggeston Grammar School, Leicester, took her agricultural degree at Wye College.

BURROUGHS WELLCOME & Co. advise us that they have introduced "Antoban" brand Piperazine Citrate for the treatment of roundworm infestation in dogs and cats. They state that this new ascarifuge is highly effective, absolutely safe and easy to administer. The dose for dogs is 0.5 gm. per 10 lb. bodyweight, for cats 0.25 gm. "Antoban" is issued as compressed "Tabloid" products, containing the equivalent of 0.5 gm. piperazine in tubes of six, bottles of 25 and 250.

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